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GEOGRAPHICAL REVIEW

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THE
GEOGRAPHICAL REVIEW

VOL. XVI JULY, 1926 NO. 3

IRRIGATION AND POPULATION IN THE FAIYÛM, THE GARDEN OF EGYPT

A. E. R. Boak

University of Michigan

THE traveler in Egypt of today who leaves the Cairo-Luxor railroad line at the junction of Wasta, 57 miles south of Cairo, and takes the branch line for Madînet el-Faiyûm soon finds himself leaving the clearly defined limits of cultivation and ascending the barren ridge to the west of the Nile valley. For a time he is entirely surrounded by desert with the ruins of the stepped pyramid of Meidum to the north as the only reminder of the fertile land he has just left. But in less than half an hour his train begins a rapid descent, and almost without warning he is out of the brown, barren waste into a land of waving palm trees, fertile fields, irrigation ditches, and flourishing towns and villages. This land is the province of the Faiyûm, the garden of Egypt. So it must have appeared to a Roman traveler of the time of Augustus, who possibly arrived by the two-day caravan route from Memphis across the desert to the north but who also may have gone farther up the Nile valley and then cut westward through the hills along a narrow cultivated gap by which a large canal entered the province. This traveler was Strabo, who spent the years 24 to 20 B. C. in Egypt. His description of the Faiyûm reads as follows:

> This nome (or province) is the most notable of all in appearance, natural resources, and improvements. It is the only nome planted with large, full-grown olive trees, which bear fine fruit. . . . It produces an abundance of wine, wheat, legumes, and many sorts of grain besides. It also contains the remarkable Lake Moeris, which is a sea in size and whose waters have a color like that of the sea.[1]

[1] *Geography*, xvii, 1, 35.

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But these flourishing conditions of the Faiyûm of today and of nineteen hundred years ago have not been constant; and in this paper it will be our task to trace in outline the waxing and waning of the various periods of prosperity experienced by this region since earliest historic times.

Throughout the winter of 1924–1925 an expedition from the University of Michigan was engaged in excavating the mound of Kôm Aushîm, which marks the site of the Greco-Roman town of Karanis on the northern edge of the Faiyûm. Its object was to recover as far as possible the archeological evidence which would aid in reconstructing the picture of the social and economic life of the region during the period of Greek and Roman occupation. Among the results of the season's work was the establishment of the relation between the fluctuations of prosperity and population in the life of this town and the periods of efficient operation and decay in the irrigation system of the province as a whole. As the Faiyûm is such an interesting area geologically as well as historically, I shall preface my presentation of the results of our work with a general account of the district and its history prior to the Greek conquest of Egypt in 331 B. C.

The Faiyûm[2]

The Faiyûm oasis lies in a great pan or depression of the Libyan desert between latitude 29° and 29° 45′ N., and between longitude 30° and 31° E. It is separated from the Nile valley to the east by a high, gravelly ridge which is pierced at one point by a natural cut. Through this cut flows a natural canal, the Bahr Yûsef, originally a drainage channel for the flood waters of the Nile along the edge of the Libyan desert. However, in ancient as well as in modern times this channel has had an artificial connection with the Nile proper. From Lahûn, where the Bahr Yûsef leaves the Nile valley to Hawâra (Hauwâret-el-Maqṭa'), where it enters the Faiyûm, is a distance of five miles. It is the Bahr Yûsef that supplies the water for the irrigation of the Faiyûm, and this water is distributed by a series of minor canals which take off from the Bahr Yûsef after the latter enters the oasis.

The area of the Faiyûm is 669 square miles, or about 1800 square kilometers, and almost all of it is fit for cultivation. The great basin of which it forms a part has an area of 12,000 square miles, so that the Faiyûm oasis is surrounded by about 10,000 square miles of desert. The cultivated land, as has been aptly remarked, takes the

[2] The authoritative general works on the geology, topography, and history of the Faiyûm are: W. M. Flinders Petrie, Hawara, Biahmu and Arsinoe, London, 1889; B. P. Grenfell and A. S. Hunt: The Position of Lake Moeris; *Egypt Exploration Fund, Archaeol. Rept.*, 1898–99, pp. 8–15; *iidem;* Fayûm Towns and Their Papyri, London, 1900; *iidem;* The Tebtunis Papyri, 2 vols., London, 1902–07; R. Hanbury Brown: The Fayûm and Lake Moeris, London, 1892; H. J. L. Beadnell: The Topography and Geology of the Fayûm Province of Egypt, Cairo, 1905.

form of an irregular leaf with the Bahr Yûsef forming the stalk and the branch canals the veins. To the north of the Faiyûm, in the deepest part of the depression, lies a lake known as the Birket Qârûn, a body of water with a surface area of some 200 square kilometers, or about 80 square miles.

Apart from a small basin in the south, the slope of the Faiyûm is northwestwards towards this lake, and the drainage naturally

FIG. 1—Map of the Faiyûm showing places mentioned in the text, the Bahr Yûsef and its main branches, and the limits of the cultivated area. The spelling of modern names on the map and in the text from the Survey of Egypt, 1:100,000 map.

follows the direction of the slope. Two deep natural watercourses terminating in the lake intersect the Faiyûm. The eastern of these is known as the Wadi Tâmîya, or Bats Drain, and the western as the Wadi Nazla or simply the Wadi Drain. Both are ravines which have been worn down through the alluvium to the Eocene sandstone below. The origin of these wadis is uncertain, but the most plausible suggestion is that they are due to water escaping in ancient times from the Bahr Yûsef when the Nile was in flood.

The slope of the land towards the northwest is not uniform. The central part between the two wadis descends in three distinct stages to the lake.[3] The first of these extends from Hawâra at 25 meters above sea level to Madînet el-Faiyûm at 22.5 m. A fall of less than three meters in ten kilometers. The second stage, which descends more rapidly, lies between Madînet and the line Sinnûris-Sanhûr-Abuksâh, which is at ten meters. Here the fall averages

[3] Grenfell and Hunt, Fayûm Towns, p. 3; Brown, *op. cit.*, p. 6.

about one meter in 1400. The final stage stretches from the Sinnûris-Abuksâh line to the lake. Here the fall is still more rapid, for the distance is barely ten kilometers, and the lake level is 44 meters below sea level.

The Faiyûm Lake

As we have noted, the lowest part of the Faiyûm depression, to the northwest of the cultivation, is occupied by a lake called the Birket Qârûn, or Lake of Horns, from the hornlike promontories jutting out from its northern shore. In 1905 it measured 40 kilometers in length from east to west, while its extreme breadth from north to south was less than ten kilometers. Its greatest depth is about five meters. The size of the lake has not changed materially since that date.[4] To the north of the lake lies the desert, to the south the cultivation.

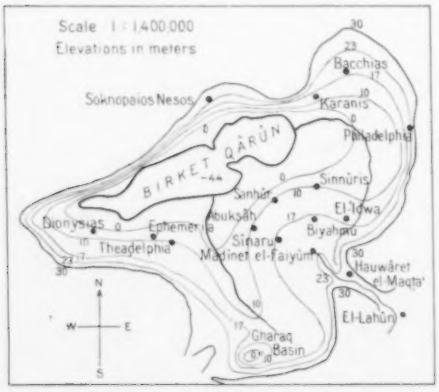

FIG. 2—A contour diagram of the Faiyûm based on Brown: The Fayûm and Lake Moeris, p. 65. The contours to the northwest of the lake are only approximately accurate.

The Birket Qârûn is maintained entirely by drainage from the Faiyûm and is shrinking steadily, since that drainage supplies less water than is lost by evaporation. Between 1885 and 1892 the lake sank at the rate of about half a meter annually, but the increase of irrigation in the Faiyûm in recent years has slowed down the rate of fall. The water in the Birket Qârûn is brackish, the total percentage of salts being 1.34, of which .92 is sodium chloride.[5]

The modern lake is the remnant of a much larger lake that once covered all or nearly all of the cultivated Faiyûm. This prehistoric fresh-water lake appears to have been caused by the Nile eating its way through the ridge separating the Faiyûm from the Nile valley in late Pleistocene times. It is estimated that at that time the level of the Nile opposite Lahûn was about 20 meters higher than at present, or about 41.50.[6] The water entering by the gap filled the depression and formed a large lake. The inflowing Nile water brought with it a load of sediment which it spread fanwise upon the lake floor, forming an alluvial deposit of mud similar to that of the Nile valley. The formation of this deposit is responsible for the sloping steps be-

[4] For the measurements see Beadnell, *op. cit.*, pp. 12–14.
[5] *Ibid.*, p. 14.
[6] *Ibid.*, p. 80; Petrie, *op. cit.*, pp. 1 ff.

tween the two wadis described above. At the same time in the northern, northwestern, and western parts of the lake an alluvial deposit of lacustrine clays and sands was slowly laid down. These deposits make it possible for us to trace the extent of the ancient lake. At some period after the formation of this great lake the level of the Nile fell greatly, and its connection with the Faiyûm may have

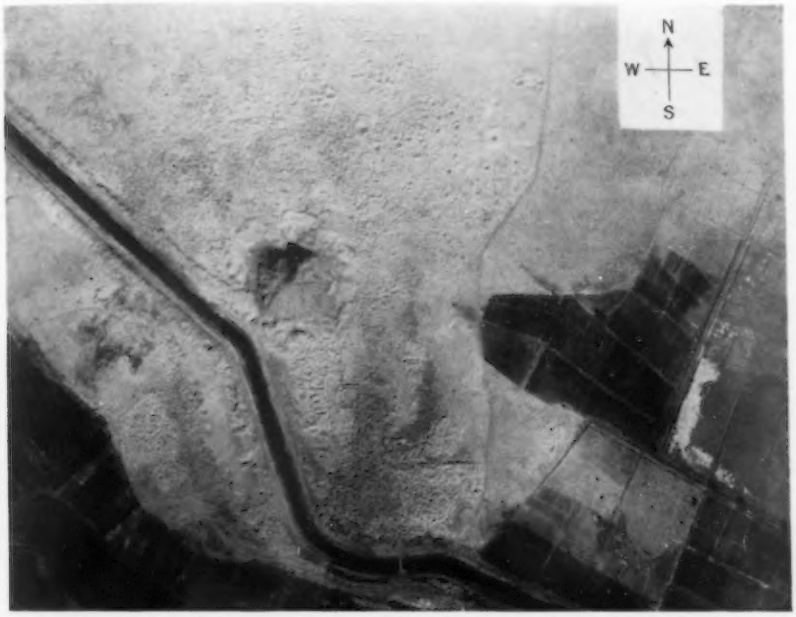

FIG. 3—View of the Hawâra Pyramid from the air, showing the Bahr Seila Canal about where it branches off to the east from the Bahr Yûsef to circle the eastern and northern sides of the Faiyûm. Fields with irrigation ditches are seen on the south and west. The pyramid is surrounded by desert.

been interrupted. Still later, with the rising of the bed of the historic Nile the connection was resumed and has continued without a break up to the present day. The upper level of this early lake seems to have been between 22 and 23 meters, and its area about 2250 square kilometers.

THE FAIYÛM UNDER THE PHAROAHS

It happens that a rock formation fixes the low level of the Bahr Yûsef between Lahûn and Hawâra at 18 meters. As a result Nile water could only flow into the Faiyûm when the flood level of the water in the Bahr Yûsef at Lahûn exceeded 18 meters. Then, as the flood subsided, water would flow back through the Hawâra channel into the Nile valley until the level of the Faiyûm lake sank below the 18-meter mark. Thus that portion of the Faiyûm

lying between the high-water level and the 18 meter mark would be inundated and drained off again in the course of each year. This area included the first of the three slopes mentioned above and a part of the second. Such land would be fit for cultivation, and villages could be built on the lake shores above high water or on uninundated eminences within the area subject to the annual inundation. The existence of a village on the site of Madînet in the Old Kingdom (*c.* 2900–2500 B. C.) shows that this section of the Faiyûm was inhabited at this early date.[7]

However, the first serious attempt to exploit the Faiyûm seems to have been made in the Middle Kingdom (*c.* 2160–1785 B. C.). Amenhemet I of the Twelfth Dynasty built a dam with flood gates at Lahûn and possibly another at Hawâra. These gates were opened at the time of the high Nile and the inflowing water raised the level of the Faiyûm as high as was desired. Then the gates were closed and both inflow and outflow were checked. The surplus flood water of the Bahr Yûsef was diverted into a canal which ran down the Nile valley from Lahûn, as the Giza canal does today. The construction of these dams converted the Faiyûm Lake into a reservoir from which water could be drawn off for the use of the fields in the Nile valley by opening the flood gates in the dry season. This reservoir is the historic Lake Moeris.

Along with the formation of the Lake Moeris reservoir went the reclamation of the district previously subject to uncontrolled seasonal inundation and possibly remaining in a marshy condition. Under Amenhemet III, apparently, the low level of Lake Moeris was fixed at 17.5 meters, and the land lying above that level in the southwest of the Faiyûm, amounting to about 27,000 acres, was redeemed for cultivation.[8] This region was treated as a modern irrigation basin—flooded at high Nile and drained when sufficiently saturated with water. It was protected from the lake by an artificial dike.

The dike served to impound the waters of Lake Moeris when they were allowed to rise above the 17.5-meter level until they were drawn off as needed for irrigation purposes in the valley. The high level of the lake is traced by a deposit of fresh-water shells. Upon this evidence it has been calculated at 22.5 meters, which would give the lake at its highest level an area of 2500 square kilometers.

We know very little regarding the subsequent history of the Lake Moeris reservoir, but it survived the decline of the Egyptian kingdom and apparently was still functioning during the period of Persian domination, to judge from the account given by Herodotus (II, 148–150) shortly after the middle of the fifth century before Christ.

[7] Grenfell and Hunt, Fayûm Towns, p. 4

[8] Brown, pp. 87–92.

FIG. 4

FIG. 5

FIG. 4—The Bahr Yûsef entering Madinet el-Faiyûm.
FIG. 5—A view on the Wadi Nezla, showing the depth of the alluvium.

Exploitation of the Faiyûm by the Ptolemies

It is not definitely known when the policy of using Lake Moeris for a reservoir was abandoned. We can only be sure that it occurred between the fifth and the early part of the third century before Christ. At some time within these limits the water from the Bahr Yûsef was shut off from the lake, and only enough admitted to the Faiyûm to flood the irrigation basin around Madînet. As a result the waters of Lake Moeris sank rapidly under the influence of evaporation until before the middle of the third century before Christ its level was below four meters. At about 200 B. C. it was practically at sea level.[9]

As a consequence of the shrinkage of the lake, that part of the Faiyûm lying between 17.5 meters and 4 meters was open for settlement and became the scene of a great project for land reclamation and colonization under Ptolemy II (Philadelphus) and his son and successor Ptolemy III (Euergetes). The story of their exploitation of the Faiyûm has been revealed by the various finds of Greek papyri from this period, especially in the recently discovered correspondence of Zenon, a Greek in the employ of Apollonius, the finance minister of Ptolemy Philadelphus from 258 to 247 B. C. The task involved the drainage of the marshland, the clearing out of bushes, reeds, and other swamp vegetation, and the construction of main and subsidiary irrigation canals to carry the water of the Bahr Yûsef to supply the needs of cultivation. The whole scheme of irrigation was directed by the Greek engineers of the government. The settlement of the newly won land was rapid. Egyptian peasants were brought in from the villages of the valley and the delta, some of them coming as voluntary settlers, others as conscripts. As a rule the peasants became tenants of the crown; but the estate of Apollonius, to whom Ptolemy Philadelphus made a grant of 6250 acres, was likewise tilled by Egyptians under the direction of Greek managers.[10] Another numerous class of colonists were Macedonian and Greek mercenary soldiers, who received land grants which often involved the bringing of untilled soil under cultivation.

How extensive this colonization was may be judged from the following facts. In the list of the towns and villages of the Faiyûm published by Grenfell and Hunt in the Appendix to Volume 2 of "The Tebtunis Papyri" there are 114 which are known to have existed in Ptolemaic times. Professor Rostovtseff has pointed out[11] that 66 of these have Greek names and are Greek foundations in

[9] Grenfell and Hunt, Fayûm Towns, p. 15.

[10] A fascinating picture of the development of the land grant of Apollonius, and incidentally a very good idea of the whole colonizing movement, is given in M. Rostovtseff: A Large Estate in Egypt in the Third Century B. C.: A Study in Economic History, *Univ. of Wisconsin Studies in the Social Sciences and History No. 6*, Madison, 1922.

[11] *Ibid.*, pp. 9–10.

which the Greek element predominated. Of the remaining 48 with Egyptian names a large number show by the form of their names that they were settlements of Egyptians brought by the Ptolemies from other sections of Egypt. Most of these towns and villages lie either on the lower part of the second and on the third of the central drainage slopes or at similar levels on the northern and southern borders of the Faiyûm. That is to say, they owed their existence to the bringing under cultivation of the Nile mud and lacustrine deposits heretofore concealed beneath the waters of Lake Moeris.

FIG. 6—The Abdalla Wahbi Canal at Karanis. View looking west towards the Birket Qârûn. To the left the cultivation below the canal level, to the right and above the desert.

In the last century or more of the rule of the Ptolemies Egypt was greatly disturbed by civil wars—a condition which caused the repairing and cleansing of the dikes and canals to be often neglected. As a result much land failed to receive the necessary water or, what was equally bad, got too much water, became waterlogged, and so passed from the category of cultivated to that of waste land. That such was the condition in the Faiyûm we have the testimony of papyri from Tebtunis and other sites.[12] How this decline in the efficiency of the irrigation system affected the Ptolemaic colonies is illustrated by the conditions found at Karanis.

Excavations here showed that the ruins of the town of the Ptolemaic period rested upon a rocky ridge which at one time possibly formed part of the shore of Lake Moeris. There were no traces of a previous Egyptian settlement; but as far as the ruins of this period were laid bare in the work of the season of 1924–1925 they were found to have been overlain by a deposit of wind-blown sand. A considerable section of the town must have been abandoned and

[12] For a good discussion of this condition see W. L. Westermann: Hadrian's Decree on Renting State Domain in Egypt, *Journ. of Egyptian Archaeol.*, Vol. 11, 1925, pp. 165–178.

have fallen into decay. This abandonment must have lasted for a considerable time to allow for the collapse of the brick walls and the accumulation of desert sand upon their ruins. It may justifiably be explained by a decline in population following a decrease in the cultivated area towards the close of the Ptolemaic period. If this is true of Karanis, many of the other outlying towns and villages of the Faiyûm must have suffered in a similar way.

Prosperity and Decline under the Principate

One of the first undertakings of Augustus after the annexation of Egypt to the Roman Empire in 30 B. C. was the repair of the irrigation canals which had lapsed into a ruinous condition through long neglect under the later Ptolemies. For this work he employed the services of the Roman troops in Egypt.[13] His renovation of the irrigation system ushered in an era of material prosperity that lasted for over two centuries.

Once more the effect of the changed conditions in the Faiyûm may be seen in the story of Karanis. A Ptolemaic temple dedicated to the crocodile gods Pnepheros and Petesuchos was rebuilt or at least rededicated in the time of Nero. Under Vespasian a new civic banquet hall was added to the temple area; and as late as the time of Commodus a propylaeum opening onto this area was repaired.[14] At some time in the first century a fine new stone temple was erected farther to the north in the town. This temple, probably dedicated to Sarapis, had its foundation bedded in the ruins of Ptolemaic buildings. The area of the town which had been abandoned and had fallen into ruin was reoccupied, new areas were built upon, and the town seems to have attained its greatest size in the second century of our era. A considerable colony of Roman citizens settled here and in the neighborhood, probably for the most part imperial freedmen and veterans from the Roman garrison in Egypt. The general prosperity of the period is reflected in the well built houses, constructed of carefully made mud bricks, with the interior walls neatly plastered and at times artistically decorated.

This era of prosperity seems to have lasted to about the end of the first quarter of the third century. Then another period of decline set in. Over a wide area these houses were abandoned. Roofs and upper walls fell in, and sand helped to fill the inside of buildings while it packed the streets and lanes outside so firmly that the lower walls were held in place for centuries until the spade of the excavator brought them once more to light. The decrease of population at Karanis coincides with the epoch of civil war and invasion which

[13] Suetonius, *Augustus*, Ch. 18.

[14] D. G. Hogarth in Grenfell and Hunt, Fayûm Towns, pp. 27 ff.

lasted from 235 to 285 A. D. and involved the disruption of orderly government in nearly every province. Once more in Egypt we have a breakdown of the irrigation system, and once more this resulted in a decline in prosperity and population, particularly in those outlying districts which depended most upon a perfect functioning of the artificial water channels.

FIG. 7—A section of the mound of Karanis, showing the ruins of walls of the three levels, the lower Ptolemaic, the middle that of the Principate, the upper that of the Empire, each separated from the other by a layer of compact sand.

THE FAIYÛM IN THE LATE EMPIRE

The reëstablishment of the unity of the Empire and a stable administration was reflected in the renewed attention paid to the Egyptian irrigation system. The emperor Probus, during his sojourn in Egypt in 280–281 A. D.,[15] followed the example of Augustus in using his troops to render the canals and dikes fit for service. Once more there ensued a revival of prosperity for the Faiyûm, but this time neither so great nor so lasting as under the Principate. The oppressive system of taxation, the spread of graft and inefficiency among all ranks of the imperial bureaucracy, the civil disturbances in Egypt caused by religious strife, and the weakening of the central imperial authority all combined to bring about a decline in the efficient operation of the irrigation system and to make agriculture a less and less profitable occupation.

[15] For the date, see W. L. Westermann: The Papyri and the Chronology of the Emperor Probus, *Aegyptus*, Vol. 1, 1920, Milan, pp. 297–301.

In Karanis the revival can be traced in the reoccupation of the district abandoned before the middle of the third century. Reoccupation began about the opening of Diocletian's reign in 284 A. D. However, it did not extend to the whole of the area built upon in the previous period. Moreover, the houses of this age were as a rule more cheaply constructed, the bricks were not so well made, the good interior plastering was lacking, and the general impression they give is one of less permanence and prosperity. No objects have been found so far which can be placed after 430 A. D., and it is highly probable that the site was abandoned by the middle of the fifth century.

The other Faiyûm town sites tell the same story. Dimai, the ancient Soknopaios Nesos, lying to the north of the Birket Qârûn, was not reoccupied after the decline of the third century. Theadelphia and its neighbor towns in the northwestern corner of the Faiyûm were abandoned in the course of the fourth century. Philadelphia and Bacchias, which probably depended upon the same high level canal as Karanis, seem to have fallen into decay at about the same time.[16]

With the failure of the border canals, the cultivated area shrank until it was restricted to the old Nile alluvial deposit in the central part of the Faiyûm. And so it remained throughout the period of Arab and Turkish rule until the revival of the irrigation system in the nineteenth century.

The Modern Parallel

With the passing of Egypt under British suzerainty there began the real modern revival of irrigation and the consequent expansion of cultivation and increase of population. Canals have now been constructed to carry water to the borders of the desert that surrounds the Faiyûm. But the abandoned area has not yet all been won back for cultivation. The process of redemption and colonization is still in progress, particularly in the northeastern and northwestern sections, and in many respects it offers a parallel to what happened in the revivals under the early Principate and the Empire.

A few figures may be given in confirmation. The population of Madînet el-Faiyûm advanced from 31,262 in 1897 to 33,069 in 1907 and 44,400 in 1917, while it is now estimated at over 50,000. As for that of the province as a whole, it increased from 200,967 in 1882 to 312,157 in 1897 and 507,617 in 1917.

[16] Grenfell and Hunt, Fayûm Towns, p. 16.

OUT-OF-THE-WORLD VILLAGES OF ATACAMA

Earl Hanson

IT IS no wonder that Toconce, Aiquina, and Caspana are called "out-of-the-world" villages.[1] The Antofagasta and Bolivia Railway lies over thirty miles to the west. The old transandean route through San Pedro de Atacama, once the main road from Bolivia and still important for the cattle trade from Argentina, runs some two-score miles to the south. The three villages lie tucked away in their respective canyons as peaceful and as undisturbed as they must have lain for centuries and as they are likely to remain for centuries to come. Although an occasional automobile does arrive at Aiquina to create a stir of wonder among the natives, the only possible ways of reaching the other two villages are on foot or in the saddle. Their location as well as their poverty makes the cost of building even a cart road prohibitive. The two automobile roads which run into the general vicinity of the three villages are unused, and one of them fell into a complete state of impassability during the heavy rains of February, 1925[2]. This is the truck road of Punta Blanca that was built and operated by the Chile Exploration Company some ten years ago, when the pipe line was laid from the source of the Toconce River to Chuquicamata. The other road runs from San Pedro inland (on the Antofagasta-Bolivia Railway), following the San Pedro and Inacaliri Rivers and swinging south around Toconce mountain to the geysers at Tatio. It was used by Italian engineers when they conducted experiments at the latter veritable "Valley of Ten Thousand Smokes" with a view to building a natural-steam power plant similar to the one at Larderello in Tuscany, but their project lies dormant pending the receipt of necessary funds.

Even the great scenic beauty of that section of the higher Andes remains happily unexploited. The few privileged visitors lose their hearts on first beholding it: the Vega of Turi, bunch grass and hummocks and sand at the foot of the snow mountains, for all the world like a transplanted bit of Iceland; the bordering range on the south, barren and weird, like a lunar landscape; the Toconce valley with all the riotous colors and grotesque formations of the Grand Canyon; and something of Colorado about the cordíllera trails, bunch grass, sagebrush, and rock strata standing on edge.

[1] F. C. Walcott: An Expedition to the Laguna Colorada, Southern Bolivia, With a Note on the Recent Occurrence of "El Niño," *Geogr. Rev.*, Vol. 15, 1925, pp. 345–366; reference on p. 358. See the map, Fig. 2, p. 348, for location of the villages.

[2] *Ibid.*, p. 363.

The Villages Self-Supporting

Their isolation compels the three villages to be practically self-supporting. The terraced and irrigated fields produce alfalfa for the beasts and corn for the humans. Llamas and mules and sheep and a herd of cows graze on the Vega of Turi in the valley of Inacaliri and on the upper slopes of Toconce mountain. In dry years the grazing is lean enough, and the surplus of animals thus created is sold for meat. But on those rare occasions when enough rain falls for abundant pasturage the beasts are fattened and bred as rapidly as possible, and the herds are increased to as large a size as the country will support. During 1925, which will be remembered for decades as the year of the big rains, large flocks of sheep were even bought in the Argentine. Instead of being driven over the shorter route through Toconao and San Pedro de Atacama, they were taken north through the Laguna Colorada Basin and the Inacaliri valley, this route having the double advantage of giving the custom officials on the cattle trail a wide berth and of affording water and a grazing spot at the end of every day's march.

There is one store in Aiquina and another in Caspana, selling mainly coca and alcohol to the villagers who remain at home and salmon and sardines to those about to travel. Both are owned by Señor Cruz of Caspana and are open alternately or closed together, according as to whether Señor Cruz is in either of these villages or away in Calama or Chiu Chiu tending to his other business interests. Occasionally an itinerant "Turkish" trader passes through the villages, offering for sale dyes and horseshoes, Sunday clothes, cooking utensils, and gaudy trinkets.

Little more is needed. The villagers have corn and meat, goat's milk and cheese; and Caspana raises apples and pears as well. The women make pottery and spin and weave the wool for everyday clothing. On their feet the natives wear exactly the same kind of sandals that one finds in the ancient cemeteries of the region. The houses are built of stone, with cactus-wood doors and roofs of straw laid on cactus-wood beams, and are generally windowless. Up to a few years ago the use of nails was practically unknown, boards being held together with wooden pegs and leather thongs. The increasing use of nails in house construction is only to be regretted, as the old leather-thong construction was far more flexible and better able to stand up under the region's numerous earthquakes.

The Villagers and Their Industries

The male inhabitants of the villages spend the spring and summer months at home tending their fields, but in winter time those who are able to get away go to work in the *llareta* harvest. *Llareta*, a fibrous,

FIG. 1—Toconce Mountain.

resinous moss, used locally for fuel and shipped to all parts of the nitrate fields for the same purpose, grows on the Andean mountain sides at altitudes of 13,000 to 16,000 feet. In the Loa basin the slopes of Paniri, San Pedro, and San Pablo are being especially exploited for this plant at the present time.

Those who have llamas and mules use them to pack the *llareta* down to the railroad or to some point whence it is hauled with trucks to the nearest station. A man with ten or twelve mules can earn a very good wage in the *llareta* harvest, each animal bringing about twelve pesos daily profit to its owner. But the mule has not yet succeeded in crowding out the ancient beast of burden of the Incas. On a visit to Polapi (on the railroad north of San Pedro) in 1924 I found about a thousand llamas used for transporting *llareta* in the vicinity. While these animals can carry only from eighty to a hundred pounds, as compared to a mule's two hundred, they cost only some fifty pesos each, the price of a good mule being often from ten to twenty times that figure. The llamas, moreover, can easily be handled in herds of from twenty-five to forty animals and need no expensive pack saddles, while a pack train of mules seldom exceeds twelve animals for every two men. The llama needs no iron shoes, does not have to be fed, and can go for days without water. It generally works seven or eight days at a time, browsing at night for what grass is to be found, and is then turned loose three or four days for a rest and a good feed. Besides, it is a valuable source of meat and wool, while the mule has nothing to offer but its labor.

Those of the Indians who own no animals work as cutters on the mountain side. They camp at the high altitudes for three or four weeks at a time, with no protection against the bitter cold of the night but a poncho, a mouthful of coca, and a small fire. Their wages are generally twelve pesos a day, out of which they buy their own food. It is a hard life, but they stick to it only for a month or two in the year.

The Atacamanians are well used to cold and high altitudes. Last year I visited the sulphur mine in the crater of Auconquilcha, which is owned by the Carrasco Brothers of Ollague and worked with Indian labor. The camp of this mine is located at an altitude of 18,000 feet, while the workings themselves are 2000 feet higher. Every working day the men have to climb to 20,000 feet, labor with pick and shovel in the midst of the insidious sulphur fumes that issue from every crack in the mountain top, and then descend the steep path to their camp at night.

It is no wonder they are inveterate coca chewers. The leaf not only immunes them against hunger and fatigue but deadens them to the disastrous effects of high altitudes as well.

To the casual visitor the natives give the impression of being phlegmatic and naïve. Unless they are actually afraid to the point

FIG. 2

FIG. 3

FIG. 4

FIG. 2—The automobile road from Calama to San Pedro de Atacama. Engineering difficulties make it necessary to station mules at one point in order to help motorists. (Photograph by J. Crane.)
FIG. 3—The corn mill on the Vega of Turi. (Photograph by J. Kenney.)
FIG. 4—Ruins of an ancient city, Rio Loa valley. (Photograph by J. Crane.)

of running away, they appear sullen and stupid. They are extremely shy and reticent about revealing themselves to the stranger; and, indeed, they generally receive little consideration from visiting gringos. I met one man, however, who seemed to have a touch of that genius and aggressiveness that built the Inca Empire. He was

FIG. 5—Natives of Aiquina in the Rio Salado valley. Terraced fields in the background.

walking over the Vega of Turi toward Aiquina and was introduced to me as "the engineer of Toconce." A dirty looking devil in ragged clothes, with his mouth full of coca, spinning wool on a primitive whorl as he went, he beamed with pride at the title. He is the chief medical authority of the villages as well, being on the way when I met him to visit a sick man and get a package of medicine he had ordered in Calama. He had become known as the engineer when he paced off a number of trails and marked the measured distances with kilometer stones. Later he began to give grades and levels for aqueducts and irrigation ditches. He does it entirely by eye, and Toconce's two-kilometer aqueduct, running along the side of an almost vertical cliff, is as good a piece of engineering work as I could accomplish with the best level and rod available. The man is also the builder of two primitive corn mills, one in Toconce and the other on the Vega of Turi, which are run by water power derived from irrigation ditches. He is a local authority on building, being responsible for the more solid construction of the newer houses of Toconce. The church of Toconce also was erected under his guidance and according to his plans. The alignment of cactus-wood beams and the straw-thatch on the roof of this church show a decided attempt at good workmanship that is lacking in those of Aiquina and Caspana. And

the rough-hewn stone pilasters behind the altar of the church, carved by himself, indicate some skill and a tendency toward simplicity, in decided contrast with the amateur overdecoration of the altar of Caspana. The engineer can neither read nor write, though he must know a little about the science of arithmetic.

FIG. 6—A view of Aiquina.

SOCIAL LIFE

It is stated that Toconce and Aiquina have a single alcalde elected annually on September eighth.[3] Inquiries made in these villages, however, indicated that the alcalde holds his position during good behavior and is appointed by the authorities in Calama on the recommendation of the judge, who resides in Chiu Chiu.

For many years these little villages paid no taxes. Turned over to Chile with the rest of the Atacama region after the war of 1878, they were left tax-free and unmolested as they had been under Bolivian rule. Now, however, that most of the old Bolivian inhabitants have died, and a new generation has grown up, a very light tax is imposed.

The benefits derived from this are, however, more or less obscure. Perhaps they consist in being allowed the use of the land which has supported the villages for generations. Certainly the Chilean government has not seen fit to give them anything like a school or a postal service. One sometimes wonders just what the word Chile does mean to these people in their isolation. When one asks them about their

[3] Luis Riso Patrón: La linea de frontera con la República de Bolivia, Santiago, 1910; *idem:* Diccionario jeográfico de Chile, Santiago, 1924.

nationality, they are merely Aiquinos or Caspanos, while a few still consider themselves Bolivians.

Certain it is that most of their outside connections lie in Bolivia. On the other side of the border are settlements exactly like their own, people like themselves, speaking their languages, Quechua and Aymara. The former is the language of Aiquina and Caspana, while some Aymara is spoken in Toconce. Nearly all of them, however, speak Spanish. At fiesta time the villages are crowded with visitors from the Bolivian highlands. To the west of them lies the Chilean desert. It is a convenient region in which to sell llamas and sheep, but it is peopled by strangers.

Churches and Fiestas

The centers of social life in the villages are the churches, of which the inhabitants are inordinately proud. Small and crude, built in the same style as the ancient Spanish churches of Chiu Chiu and Conchi Viejo, the age of these edifices is nearly always overrated by visitors. The fact is that the church of Aiquina was built in 1917, while those of Caspana and Toconce are still newer. Only the crude bells, cast in the seventeenth and eighteenth centuries, and a few interior furnishings can lay any claim to antiquity. The Caspana church is by far the most elaborate of the three. Externally very similar to the other two, it gains its distinction through its interior furnishings. All three of the churches have their *Santos*, wax effigies of the Virgin and other saints, some three and a half feet high, gaudily dressed and set on litters so they can be carried around the village at fiesta time. Caspana church boasts four of these, the most elaborate one representing a crusader on a galloping charger. The three villages are served by the same priest, who resides at Chiu Chiu and also takes care of the church at Conchi Viejo. He visits Aiquina, Caspana, and Toconce two or three times a year, at fiesta time or when a man of some importance dies. He is highly revered. I have seen men and women kneel down to kiss the hem of his gown.

His visits are, however, a severe drain on the resources of the natives. Beside requiring food and drink, a house, and the services of a cook for the duration of his stay, he charges from forty to sixty pesos and a few sheep for every mass said, the price varying with the importance of the ceremony. A wedding, for instance—all marriages are postponed until his arrival—does not cost nearly as much as a special service to rid the fields of rats.[4] One can imagine what Aiquina's main fiesta, lasting over a week, during which time from three to six masses are said daily, must cost the natives.

[4] The *chilulu*, a ground rat which infests the region and honeycombs the ground.

FIG. 7

FIG. 8

FIG. 7—The band at the Aiquina *fiesta*. Note the standard with three crescents bearing little brass bells.

FIG. 8—Farmhouse on Vega of Turi. Note the door of cactus wood.

Another person in Chiu Chiu, the wealthy widow, reaps her harvest from the simple faith of the villagers. In the spring of every year she has a large jug of sea water shipped up from the Pacific Ocean. After the priest has blessed it she sends it to the interior, where it is sold at exorbitant prices to the natives. They put it in small containers and set it in their corrals. Unless somebody has been wicked, it is sure to bring enough rain for fat crops and a prosperous year.

Each of these villages has its own special feast day, dedicated to its patron saint. Throughout the year innumerable fiestas are celebrated by the three in common. Easter is the only one of the conventional religious holidays that is observed, Christmas being neglected entirely. New Year's Day is also the occasion of a drunken orgy. At the feast of the Llama, during the breeding time of these animals, the beasts of burden are decorated with red woolen threads tied into their ears and their backs and serving for identification as well as for decoration. September 18, the Chilean national holiday, is entirely overlooked, though some attention is paid to August 6, the Bolivian day. The cleaning of the irrigation ditches in springtime, a piece of work done by the whole village in unison, is attended by much drinking and a ceremony, clearly a pagan remnant, of throwing coca leaves into the river or the spring whence the water is drawn.

But the principal fiesta of the year lasts a week and takes place around September 8, the day of the miraculous image of the Virgin of Aiquina. It was my good fortune to witness part of this fiesta in 1923. For days I had seen people leaving Chiu Chiu, on mule back and on foot, to journey to Aiquina. When I rode there myself I passed two men and a woman on donkeys and three men walking over the burning desert. Aiquina was crowded. The whole populations of Toconce and Caspana were there. Visitors had come from Conchi and San Pedro, from San Pedro de Atacama, from Calama, from villages on the Bolivian side of the border. One party of Chilean engineers had arrived in a car from San Bartolo. Men and women sat in the streets and ate, sat in the houses and played the guitar and drank. Some drank raw alcohol mixed with coca leaves, others a villainous mixture of red wine and papaya juice.

Out in the plaza a band of musicians danced around a drummer and a standard of crescents and jingle bells, playing a melancholy pagan melody on reed pipes. They were wandering minstrels from Bolivia who go from village to village, from fiesta to fiesta. One wonders how many weary miles they walk over those desolate mountain trails, through a country where settlements are often days apart.

The villagers began to dance, men and women hooked arm in arm, whirling around, laughing and joyful, around and around one way until they grew dizzy and then reversing and whirling the other. Little boys lit bunches of firecrackers and threw them among the dancers.

Suddenly a terrific din arose in the church tower. Boys were pounding fiercely on the three old copper bells calling the congregation to mass. After the service they carried the figure of the Virgin and those of two saints through the village.

Travelers in Bolivia tell of Indian fiestas in that country similar in nature to the Aiquina celebration, except that in Bolivia the par-

FIG. 9—The church of Caspana.

ticipants wear masks and gaudy feathered ceremonial costumes. In 1923 Aiquina owned neither a mask nor a costume, but on a later visit one of her inhabitants proudly showed me a collection he had acquired from an itinerant trader. There were about ten different masks with the grotesque devil motif predominating, but nearly all the costumes were shabby Romeo suits that had been cast off by some carnival outfitter. On the whole, the fiesta gives one the impression of being a heathen celebration, to which a few Christian touches have been added.

ANCIENT CUSTOMS

Many of the customs of the region can definitely be traced back to prehistoric days. For instance, the practice of building a chapel at some high point of the trail near the immediate approach to the village is said to have originated with the ancient Incas. In olden days it

served for offerings of coca; today candles are burned in the chapel for the edification of the village's patron saint. The burial custom is clearly a survival of heathen days. When a man dies the whole village goes into a form of mourning, which grows ecstatic as vast quantities of *chicha de mais* and raw alcohol and coca leaves are consumed. When he is buried, a few days later, the orgy is repeated. Eight days after his death his clothes, his poncho, and his bedding are taken to the river and washed, all the women helping in the task and the men getting drunk. The clothes are then stored away for a year, during which time nobody may touch them. Not even the visiting gringo, offering fabulous sums for a native poncho, can induce anybody to disturb the effects of the dead man. A year later the articles are loaded on a llama, and the beast is killed and buried with its burden in a new grave, away from that occupied by the body of the deceased. If the dead man had no llamas, a dog is made to serve the same purpose.

These people have innumerable superstitions and omens of good or bad luck, some of them probably ages old and others springing up as occasion demands. On my last visit to the interior, after some three years of intermittent rummaging among the villages and ancient cemeteries of the vicinity, I was surprised to hear that my appearance was an unfailing indication of three days of hard wind to follow.

Origin of the Villagers

But my continued questioning and searching entirely failed to bring to light out of the many superstitions any legends or folklore which would indicate that these people have any feeling of connection with the ancient Atacamanians, whose remains litter the countryside. A few miles from Aiquina, on the Vega of Turi, lie the ruins of an old city of copper workers, in which the Spaniards had evidently built a few adobe houses. What do these ruins mean to the present population? Absolutely nothing, as far as I could find out. They were inhabited by another people that is now gone, *Dios sabe adonde*. They were a wealthy people, that is all anybody knows about them. Most of the natives have seen blue flames arise from the ground near the old ruins, a sure sign of buried treasure. But they haven't been so foolish as to look for the gold. For he who disturbs the remains of the ancients must surely grow sick and will probably die.

This superstitious fear seems to be their only definite attitude toward the old remains. Certainly I have never been able to detect any sign of reverence. On the few occasions when I ventured to do some excavating in an old burial ground, I found that the natives harbored resentment toward me only to the extent that they were afterward afraid to pass the spot. They told me how incredibly foolish I was to risk my life in such a fashion.

That I have never come across any indication of legend or folklore in any of these three villages does not, of course, mean that such does not exist. Boman says that "the Atacamanians have conserved many ancient traditions, which it would be of the greatest interest to collect as soon as possible, before they are lost forever. This should be done within the next few years, for they will be forgotten with the language. The task of gathering this folklore is far from an easy one, the Atacamanians being exceedingly reserved regarding these things."[5]

I wish Boman had visited the Rio Salado Basin and commented on Aiquina, Toconce, and Caspana. Several things seem to suggest that the present inhabitants are not descendants of the Atacamanians who smelted copper on the Vega of Turi and the banks of the Rio Toconce before the advent of Almagro but that, on the contrary, the original indigenous stock disappeared in some way and the ancestors of the present inhabitants came over from Bolivia. The natives of these villages are said to be of an "Inca" type. Yet the pottery found in the ancient cemeteries of the vicinity fails to show any Incan influence: certainly the collection I brought back from the banks of the Toconce River is purely Atacamanian. The natives of all three of these villages are able to speak Spanish, but they speak Quechua and Aymara among themselves. In the neighborhood of San Pedro de Atacama, on the other hand, it was the ancient Atacamanian language that was dropped for Spanish.[6]

A great deal of patient research is necessary to establish the anthropological background of this region, which has been almost entirely neglected by scientists.

[5] Éric Boman: Antiquités de la région andine de la République Argentine et du Désert d'Atacama 2 vols., Paris, 1908; reference in Vol. 1, p. 65.

[6] *Ibid.*, Vol. 1, p. 63.

THE AHAGGAR: HEART OF THE SAHARA

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THE name Ahaggar has dominated all exploration of the western Sahara during the latter half of the nineteenth century: it was the problem to be solved, the inaccessible core. Barth followed its eastern confines. Duveyrier gathered valuable data on the region though he did not penetrate it. Flatters with all the members of his expedition was massacred at Tin-Tarabin, where a memorial has now been raised by the French government. The Foureau-Lamy expedition crossed the Sahara but touched only the eastern margin of the Ahaggar. The name recalls a whole series of efforts, valiant indeed but futile or incomplete.

Solution of the problem remained for the twentieth century. Two successive reconnaissances by meharists from In-Salah finally dissipated the mystery. The first was under the leadership of Lieutenant Cottenest, the second under Lieutenant Guillo-Lohan. The first geographical account of exploration in the Ahaggar appeared in 1903 over the signature of the latter officer.[1]

From this time the French meharists have policed the Ahaggar and the entire western Sahara of which the Ahaggar is the key. The credit for this work of pacification rather than conquest is due to General Laperrine, now dead and buried in the Ahaggar to which he had consecrated his life. The magnitude of his accomplishment has not received the recognition it merits.[2]

Today the Ahaggar is one of the best known regions of the Sahara. The works on it have multiplied since 1903. We do not yet possess a topographic map on a large scale; but itineraries from the French posts have furnished traverses in all directions and are tied to a number of astronomically determined points. This is the basis of the General Staff's millionth map of the Sahara.

Furthermore, the region has been visited by several scientific expeditions. The geologist Chudeau made observations in the western part of the Ahaggar.[3] A philologist, M. Motylinski, sojourned in the Ahaggar in 1906.[4] The Transafrican Railway Commission,

[1] Lieutenant Guillo-Lohan: Un contre-rezzou au Hoggar, *Renseign. Colon.* (*Suppl. à l'Afrique Fran¸aise*), 1903, pp. 205–215, 239–246, and 257–267.

[2] E. F. Gautier: La Conquête du Sahara, Paris, 1910.

[3] René Chudeau: Sahara Soudanais (Missions au Sahara, Vol. 2), Paris, 1909.

[4] Voyages à Abalessa et à la Koudia: Notes de M. Motylinski, *Renseign. Colon.* (*Suppl. à l'Afrique Fran¸aise*), 1907, pp. 257–270.

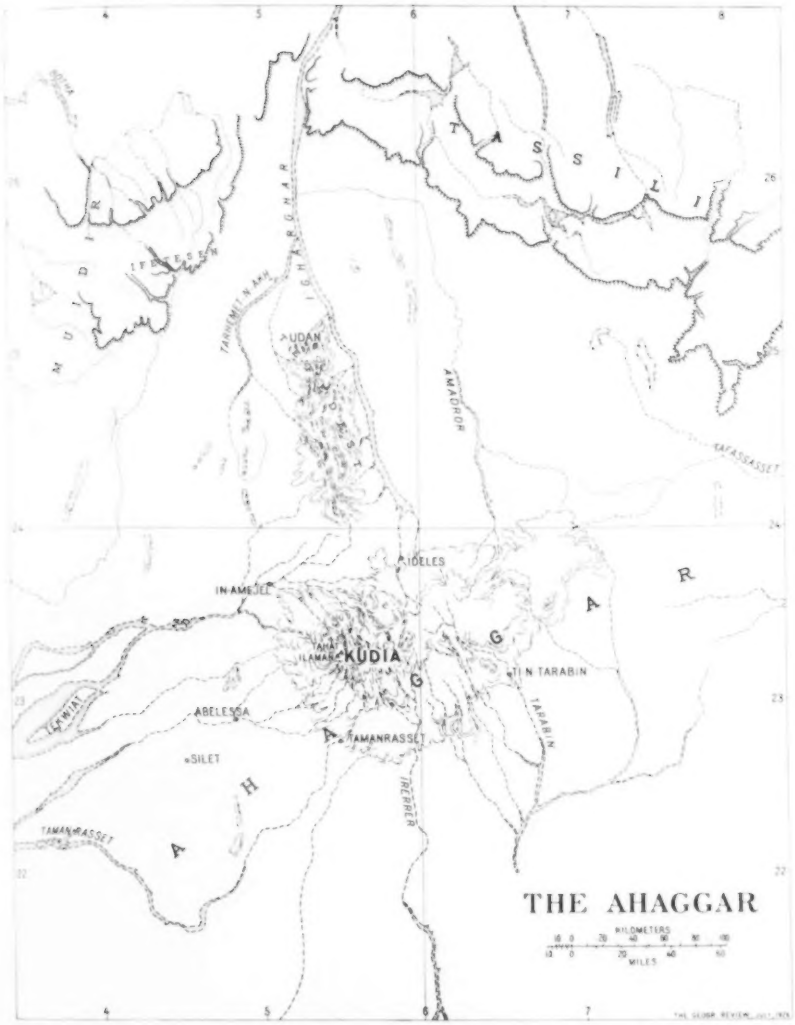

FIG. 1—Map of the Ahaggar. Drawn from the Croquis du Sahara au 1,000,000, Service Géographique de l'Armée: In Salah (1924), Fort Charlet (1925), In-Azaoua (1925), and Fort Laperrine (1924) sheets. Scale approximately 1:4,500,000.

led by Niéger and including Chudeau and many engineers, worked in the same part of the country.[5] A priest, Father Foucauld, massacred in 1917, lived ten years in the Sahara as a hermit and compiled a dictionary of the native language, the Tuareg.[6]

The war, from the influence of which even the Sahara was not exempt, naturally interrupted the scientific work. It was resumed

[5] In course of publication by the Société de Géographie of Paris.
[6] Dictionnaire Touareg (dialecte Ahaggar). Algiers, 1918.

in 1921 when Mr. Bütler, a geologist of Geneva, accompanied a small expedition whose ends were primarily commercial.[7] In 1922 Conrad Kilian achieved some very interesting results.[8] In 1923 a Danish expedition under Mr. Olufsen worked in the heart of the Ahaggar. Its results have not yet been published integrally, though M. Bourcart, the geologist, has made a preliminary report of great interest.[9] The Citroën automobile expedition touched the Ahaggar and, though without pretending to be a scientific expedition, carried an excellent photographer and professional topographer.[10] Finally the ethnographic expedition of Count de Prorok and M. Reygasse has recently returned from the field.

The People of the Ahaggar

The Ahaggar is inhabited by the people who have given it their name. The Arabs pronounce it Hoggar but, as there is no G in their alphabet, write it Hoouara, a name celebrated in medieval history in Tripolitania, Algeria, and Tunisia. The Ahaggar are the remnant of a well known Berber tribe, who from century to century ranged along the borders of the Mediterranean. Today they constitute a clan of the great Saharan tribe of Tuaregs. If not predominant in numbers they are at least the most famous, the fiercest, the most indomitable. They exercise direct control over three massifs, the Kudia, the Tefedest, and the Muidir in the heart of the desert. Of these the Kudia is most important because most populous. It is the only part of the Ahaggar where villages are to be found, if indeed the term village be not too ambitious. The villages are on the periphery of the Kudia at the debouchments of the great wadis. They consist of a collection of huts of hardened clay and are occupied by a limited number of slaves who water the miniature gardens from wells sunk in the wadi beds.

In the Tuareg tongue these villages are *arrem*. They are not true oases. For true oases one must look to the basins of the lower Sahara where converging slopes collect subsurface water. The Kudia on the contrary is a watershed. The best-known *arrem* is Tamanrasset, now on the way to becoming a little French center. Here are the tombs of Laperrine and Foucauld, and it has been proposed to build a hotel to accommodate future tourist traffic. Other *arrem* are Abalessa (site of the tomb of Tin Hinan), Silet, Ideles, Tin-Tarabin.

[7] Henri Bütler: Contributions à la géologie de l'Ahaggar (Sahara central), *Comptes Rendus Congrès Géol. Internatl. XIII, Belgium, 1922*, fasc. 2, Liége, 1925, pp. 819–848. Received while M. Gautier's paper was in press—Edit. Note.

[8] Conrad Kilian: Au Hoggar, Paris, 1925.

[9] Jacques Bourcart: Un voyage au Sahara: Note préliminaire sur les résultats géologiques de la Mission O. Olufsen au Sahara, *Renseign. Colon. (Suppl. à l'Afrique Française)*, 1923, pp. 385–408 and 442–459.

[10] G. M. Haardt and Louis Audouin-Dubreuil: Le raid Citroën; La première traversée du Sahara en automobile, Paris, 1924.

These are their names, but they are of no importance, being insignificant enough in the general scheme of things. The Kudia cannot be an agricultural country. Thanks, however, to its altitude it arrests the passage of a greater number of storms than the surrounding wilderness. Kilian and Bourcart have observed on its summits, Tahat in particular, a persistent cloud cap from which an abundant moisture is deposited. It is sufficient, for instance, to saturate the paper of one's field notebook. Pasturage is found not only in all the valleys but even to the summits. The matter of temperature also is important. In winter precipitation on the highest elevations takes the form of snow which may last for the day. In summer the temperature of the Kudia is lower by twelve degrees or more than the neighboring regions of the Sahara. An important fact; for, after all, the Ahaggar are of the white race and live in the tropics.

Goats, sheep of a peculiar species, and asses browse on the herbage of the Kudia. Infrequently also zebus may be seen, brought from the Sudan; but it is the camel that is the important beast, the means of subsistence.

The pure-blooded Ahaggar does not engage in cultivation. Under no pretext will he handle an implement of toil. His hand, unaccustomed to manual labor, is small, quite out of proportion to his powerful frame and muscular body. The delicacy of his extremities is aristocratic. The hilt of the Ahaggar sword is too narrow for a European grasp. The Ahaggar is exclusively a gentleman of the sword. He has always lived on his courage. With the Kudia at the center of the Sahara as a retreat, mounted on his meharist camels trained admirably as their masters, the Ahaggar has been for centuries master of the transsaharan routes. According to his enemies he pillages the caravans; in his own view it is the levy of a legitimate toll. Certainly he gets his living from the transsaharan traffic.

This specialized life has developed a psychology, an ethos, which has forcibly struck all European observers from the time of Duveyrier to the most recent expeditions. It should be studied now before the old life changes and the Ahaggar become chauffeurs or garage mechanics or railway employees.

The Ahaggar have already been described many times;[11] we shall here note only an aspect of the clan that is of particular geographical interest—what may be called its relict character. Certainly this is not a true description of the outward appearance of the individual, for he is a superb creature, tall, slender, muscular, keeping his force and agility to an advanced age. In a magnificent envelope a superb soul: of great energy, scornful of death, and yet possessing poise and

[11] Henri Duveyrier: Les Touareg du Nord, Paris, 1864.
E. F. Gautier: La Conquête du Sahara, Paris, 1910.
Conrad Kilian: Seul au Hoggar, *Vie Tunisienne Illustrée*, May, 1923—a brochure marked by rare feeling and warm sympathy.

moderation, courtesy and chivalry, one might say a sense of fair play. Nor is his mind to be underrated: refined by relentless strife against the exigencies of a hostile nature, it is a mind open, curious, eager to learn. The Ahaggar has the soul and body of a gentleman practicing for generations the hardest and most dangerous sport—a gentleman of the desert highway.

FIG. 2—Ahaggars in war costume. Note the veil, *litham*, covering the mouth. (All photographs, except Fig. 8, by Désiré.)

But when, instead of the individual, one considers the group the picture is less brilliant. Numerically the clan is insignificant in the extreme. The Ahaggar cannot assemble more than 400 warriors though all males between 15 and 60 to 70 years are under arms. Perhaps this fact increases the admiration roused by their former exploits, especially if one considers their armament—the buckler, broad-sword, and lance. They have always been poor, and they live too far from the sea to obtain more modern weapons. These 400 lances prevented the entry of Arabs and Europeans alike until 1903—an extraordinary exhibition of prowess. But so small a human group cannot offer indefinite resistance to the advance of modern civilization: they have a fine past but no future.

To what degree they are a people of the past certain details of equipment and customs bear striking witness. In the matter of writing, they alone amongst the Berber of North Africa have retained the use of Libyan characters which everywhere else disappeared not only before the Arabic but before the Roman alphabet. They use an iron ax, but the handle is attached in the same manner as the Neolithic stone axes. They make and wear polished stone bracelets. The most striking feature of their personal appearance is the veil covering half the figure, the *litham*, as the Arabs term it. Its purpose is to protect

the mouth from harmful magic, for it is the gate of the breath, that is the soul. The family organization of the Ahaggar has a matriarchal basis: juridically speaking, the father is a nonentity; the nearest male relative is the maternal uncle. By a curious consequence the ultra archaic character of the Ahaggar family has a false air of modernity. The men are inferior creatures; the women have the monopoly of intellectuality; they are the literati, poets, musicians. The Ahaggar

FIG. 3—Ahaggar man and woman. Note the narrow sword, blunt and with slender hilt, and the violin on the woman's knees.

in good faith declare themselves Mohammedans. In reality their religion is an animism surviving from prehistory.

THE TOMB OF TIN HINAN

On this picture the sepulcher excavated by Count de Prorok throws a new light. It is at Abalessa. It has been photographed by Motylinski and described by Chudeau. The natives call it the tomb of Tin Hinan and consider her as their common ancestor—maternal, of course; for, as we have said, descent is reckoned in the female line. This is the tomb opened by the de Prorok expedition. At least so it appears. The Algerian papers have published a protest by the adjutant Chapuis, chief of the post, who gave the expedition authority to excavate and who took part in the operation. According to Chapuis the tomb was not that of Tin Hinan but another belonging to the

same group. If the Ahaggar, he says, who fortunately do not read the newspapers, learned of the boasted removal of their ancestral mother, "comme ils sont intelligents ils réclameraient des dommages et intérêts." However, the person of Tin Hinan, more legendary than historic, does not mean much. What is certain is that among the innumerable dry stone monuments that strew the Ahaggar Count de Prorok has opened one which is the tomb of an Ahaggar dignitary. The tomb is of careful workmanship, and found with the body, interred according to a custom different from present-day Mohmammedan rites, are interesting burial furnishings. These furnishings are relatively sumptuous, including a number of gold and silver objects.

The date of the sepulcher can be approximately determined, since it includes gold money of Constantine on the one hand and on the other is characterized by evidences of pre-Islamic rites. We infer that it was within a century or two of the sixth century of our era. It would be absolutely impossible for the Ahaggar to raise such a monument today. This gives us for the first time a specific sign of retrogression among the Ahaggar. We are certain that in the Middle Ages they were a people notably richer and more powerful than their wretchedly circumstanced descendants. This is the only new fact that we learn from the burial furnishings of Tin Hinan; but it is quite new and confirms our idea of the Ahaggar as a relict people.

Dry stone tombs abound in the Sahara and in all northern Africa. A considerable number have been opened with negative or insignificant results.[12] This is the first time that an excavation of this kind has produced interesting fruits. It is an encouraging sign.

Physical Geography of the Ahaggar

Such are the people: let us now look at their country. A sketch of the physical characteristics of the Ahaggar is easily given, for its structure is very simple. It is a peneplain of old schists, gneisses, mica schists, and quartzites with intrusive granitic masses. The schists show evidence of intense folding, the folds extending approximately in a north-to-south direction, that of Tefedest on the map. Once there existed here an old mountain chain; but it long since disappeared, reduced by erosion to a peneplain. Suess proposed for it the name Saharides.

In the northern part, resting on the peneplain, are plateaus of red sandstone, very extensive and many hundred meters in thickness. There is the Muidir to the west, the Tassili to the east. Kilian has advanced a new and most interesting idea regarding these plateaus. In the uppermost layers Lower Devonian fossils were reported some time ago. In the middle clayey layers Kilian found Silurian fossils

[12] E. F. Gautier: Sahara Algérien (Missions au Sahara, Vol. 1), Paris, 1908, Pl. 15, opp. p. 66.

FIG. 4

FIG. 5

FIG. 4—Looking towards Tahat and Ilaman from the west. In the foreground may be recognized the old peneplain, slightly dissected; in the background note the horizontality of the lava cap from which rise Mt. Tahat, the mass in the center of the picture, and Ilaman, the needle peak to the right.
FIG. 5—"Needle" landscape in the Kudia.

(Gothlandian). We draw the conclusion that the red sandstones are of Silurian age at least. Kilian believes that the basal layers are Cambrian; but this is purely hypothesis. His discovery has been fully confirmed by the Olufsen expedition. It is established beyond question and is a fact of importance.

The chain of the Saharides had already been reduced to a peneplain when the Silurian sandstones were deposited, since they rest horizontally on its surface. Hence the elevation of the chain dates from a very early geological period—Cambrian or Algonkian. There are other parts of the earth where ancient sediments—Silurian and Cambrian—are still found in horizontal layers, intact as they were deposited. To such massive and resistant areas the term of "shield" has been applied: as the Siberian shield, the Canadian shield. The Ahaggar is promoted to the rank of a planetary shield.

Yet rigidity does not signify absolute immobility. The Ahaggar peneplain, as we see it today, is no longer cut by a horizontal plane. Its surface as a whole is affected by an immense regular uplift in the form of an exceedingly flat dome. The slope outward from the center is so slight as to be imperceptible to the eye of the traveler. One can go from In-Salah, the last oasis of southern Algeria, which is in latitude almost 27° N. on the northern border of the shield, to the Ahaggar, the central dome of the shield, which is cut by the Tropic, without being aware that one is rising. In-Salah is 200 meters above sea level, and the pedestal of the Ahaggar is in the main above 2000 meters; but the difference, evenly distributed over a distance of 500 kilometers, gives only the insensible gradient of some 4 millimeters in a meter.

If this uplift, which presumably is the result of intense lateral pressure, has caused great ruptures in the shield in the form of extensive faults, they are yet to be discovered. Probably they do not exist. There are however numerous small ones, fissures by which volcanic eruptions have had play. Some volcanoes, the least numerous, are still recognizable by their form; but those which have been so worn down that their central chimney, at least on superficial examination, can no longer be found are represented by numerous lava flows too fresh to be considered old. They do not date back later than the Pliocene. This gives an approximate date for the uplifting of the peneplain: it is comparatively late in the scale of geological time.

To the north of the shield of the Ahaggar there runs a recent chain of Alpine age, the Atlas, whose overthrust folds attest the energy of the compression from the north. The volcanic eruptions and the uplifting of the peneplain are presumably connected with the uplift of the Atlas.

Volcanic eruptions took place in various parts of the peneplain, but they were far from being distributed evenly over its surface.

They were most numerous in the most elevated part, precisely at the summit of the dome. / Here is the thick lava cap that furnishes the chief relief and gives the Ahaggar its dominating position in the western Sahara. This lava cap, studied in particular by Bourcart, is composed of three successive flows piled one on top of another, at the base phonolites, above basalts, at the top trachytes. The whole series form a crust under which the old peneplain has completely disappeared. In diameter the cap attains a breadth of 70 kilometers: the thickness of the superposed flows is many hundreds of meters. The extreme summits attain heights of nearly 3000 meters in the peaks of Tahat and Ilaman. To this lava cap, so clearly individualized by its composition and altitude, the natives give a particular name; they call it the Kudia of Ahaggar. It is the Ahaggar par excellence, the grographical *raison d'être* of the country we call the Ahaggar.

Fluvial Erosion

The uplifting of the surface of the peneplain by modifying the slope gave new force to erosion and rejuvenated the land form. Although we have in the heart of the Sahara the finest example of a desert on our planet, the Ahaggar everywhere exhibits traces of fluvial erosion. It is the most distinctive feature of the physical geography of the country.

An examination of the map shows the Kudia of the Ahaggar as a watershed whence a great network of valleys diverges towards all parts of the horizon: towards the north the Igharghar, which ends in the depression of the great shotts near Biskra; towards the west the Tamanrasset with its affluent, the Tekwiat, which ends in the closed basin of the Juf, north of Timbuktu; towards the south the Tin Tarabin and the Irerrer, which after their junction with the Tafasasset join the lower Niger. Each of these great valleys has a close network of affluents. A first glance at the map suggests a normally well watered country. In reality these valleys so clearly delineated on the map do not carry rivers, large nor small; they do not even merit the term wadi, for they have not the tiniest trickle of running water. It is the skeleton of a dead river system; they are fossils.

Farther down in their lower courses in the zone of deposition the skeleton character is betrayed. The continuity of the network is broken; sections of the valleys have been effaced by the wind, invaded by sand; the work of dissolution has become apparent. But here in the heights and the borders of the Kudia one could be deceived from a study of the map alone, so admirably is the skeleton preserved.

It is an irrefutable testimony to a relatively rainy period which preceded the present period of extreme aridity. It is the Saharan

equivalent of what we call the glacial period, what the French a half-century ago knew as the diluvial period, and the Germans still call the Pluvialzeit. As cicatrices left by the Pluvialzeit on the earth's surface the dead wadis of the Ahaggar are a good counterpart of the terraces of Lake Bonneville, the Quaternary ancestor of the Great Salt Lake, and they deserve to be as well known.

Morphological study of the dead valleys, as far as it is possible, leads to some interesting conclusions. The valleys indicate erosion arrested in the youthful stage. The simplicity of the pattern is significant. The valleys radiate regularly from the Kudia as center, each of them almost rectilinear; that is, in the terminology of the American physiographers, they are consequent or, as the French have sometimes termed it, primitive. It is true that at certain places subsequent trunk streams run contrary to the general slope and from an examination of the map one can discern captures. This is in particular the case in the great peripheral depression on the edge of the sandstone plateaus of Muidir and Tassili to the north. One suspects that the Wadi Amadror has been captured by the Igharghar. Above the point where the Amadror shows what appears to be an angle of capture its high valley is a long straight line in the exact prolongation of which the wall of the sandstone cuesta is deeply cut. Similarly it may be suspected that across the Muidir, pierced through and through by deep canyons, the Wadi Tarhemert-n-Akh, now a left-bank affluent of the Igharghar, was formerly the source of the Botha.

Much farther to the south at the very foot of the Kudia, upstream from In-Amejel, a group of little wadis, sources of the great Wadi Tekwiat, run in an east-west direction; they appear to have been captured by the Wadi Tekwiat to the detriment of the Igharghar. It is true that the erosion is not the sole cause; Bourcart thinks a lava flow has dammed the original valley.

These captures, which deserve further study, do not affect the impression of the youthfulness of the drainage as a whole; and this is accentuated if we take into consideration the profiles of the wadis. As the map shows at certain points, there is excessive enlargement of the stream bed, sometimes even bifurcation into great deltas (W. Tekwiat). Under another climate the enlargements would be lakes or marshes. In the Ahaggar these alluvial plains are sometimes encrusted with salt, Sebkha of Amadror for example, but most often they betray a dampness which supports pasture. Their importance the natives have recognized by naming them *maaders*. These valley steps are connected by narrow and deep canyons where the river, if it flowed, would form rapids. Such contrasts are characteristic of young valleys. The anthropologist by examining the dentition, sutures, etc. of a human skull can approximately determine the age of the

FIG. 6—A canyon in the Muidir sandstone.

owner at death. Examining in like fashion the skeleton of the dead rivers of the Ahaggar one reaches the conclusion that they died in adolescence, long before finishing their work of erosion.

These findings are in accord with those of geology. In northern Africa and the Sahara geologists have revealed a series of epochs in the past during which an arid climate prevailed.[11] The relatively humid period which preceded the present appears to have been an incident in a long climatic past. And there remains the present climate of frightful aridity. Thus in the Ahaggar the desert physiognomy coexists with the forms of fluvial erosion. This gives the country its most picturesque, most photogenic aspects.

FIG. 7—The inaccessible summit of Mt. Ilaman.

THE DESERT LANDSCAPE

One need not look in the Ahaggar for the sand dunes which imagination so freely associates with a desert country. The obstacle to their formation lies not in the climate but the altitude. The Ahaggar is the up-valley zone of the dead valleys. There is some sand with which the wind makes play but in insignificant amounts. The great mass of the dunes are found down valley, much lower, outside the Ahaggar in the zone of deposition where enormous quantities of alluvium furnish material for the building of dunes.

The Ahaggar is especially the desert of stones: of bare rocks or great plains of pebbles and gravel. It is said that the camels of the country, perfectly at home in traversing the rough rock edges, are less at ease in the low country on the yielding sand of the dunes. It is an extremely striking thing, this preponderance of bare stone swept

[11] E. F. Gautier: Structure de l'Algérie, Paris, 1922, p. 61 and following.

and polished by the eternal wind and veneered by the desert patina in all shades of deep red, brown, or black. Desert erosion, furthermore, has sculptured the rock in fantastic forms.

It was long believed that the most elevated point of the Kudia was Mt. Ilaman, 2950 meters. Today it is certain that a neighboring peak Tahat is higher by some dozens of meters: it is estimated at 3000 meters. The error of earlier observers is readily explained by the arresting form of Ilaman, a slender rock pyramid, almost columnar. No one has made the ascent, and manifestly it could not be made without adequate equipment.

FIG. 8—Volcanic peak (basalt) in the Kudia. (Photograph by Kilian.)

Another summit of the Ahaggar, said to be still more formidable, is Mt. Udan. It is somewhat less elevated but gains from its position as a solitary peak at the northern extremity of Tefedest, a region where the general base is appreciably lower. Its 2770 meters hang over the great Igharghar valley, here only 865 meters above sea level. This is the summit which has made most impression on the natives. They have named it Garet-el-Jenun, the needle of the Jinns. They consider it inaccessible to ordinary mortals, and legends of its fairy inhabitants and enchanted gardens have been collected by Kilian.[14] These are the giant needles: there is an infinite number of medium-sized and small ones: the country fairly bristles with them. The abruptness of the slopes of which the needles are one expression has another in the innumerable canyons, one of the great beauties of the Ahaggar. The finest perhaps are in the highest part of Muidir, Ifetesen, where the sandstone plateau attains a height of 1000 meters.

[14] Au Hoggar, p. 155.

There are narrow canyons many thousand meters deep whose walls are vertical or in some instances indeed slightly overhung. This precipitousness of slopes is of course a classic product of the desert climate. The Alps also are strewn with innumerable needles, but these adorn the summits of a mountain chain enclosed by the glaciers that have sculptured them. There is nothing of this in the Ahaggar, no least trace of glaciation and no chain.

In the Kudia also a comprehensive glance easily discerns the level character of the lava flows dissected though they have been by the network of canyons and needles. Outside of Kudia plane surfaces largely predominate—here of the lava flows, there the uniform surface of the peneplain, and again of the gravel plains known to the natives as *reg*. From the level surface the needles rise with startling abruptness: they appear to be set on the plains, as Chudeau says, like bottles on a table.

This is the work of the climate in the modeling of the desert landscape. It is not as great as is generally supposed. All who have seen the western Sahara have been led to the conclusion that the potency of eolian action has been exaggerated.[15] The desert climate, of which the wind is a fundamental agent, amplifies the contrasts of existing relief and thus produces results so striking as to be in the nature of caricatures; but it does not create. It is fluvial erosion that has originated the relief on the borders of the great sandstone plateaus as also the considerable mass of Tifedest, a region still little known, which Kilian and Bourcart tell us is a granitic massif. The granites and Silurian sandstones are in fact more resistant to erosion than most of the old schists, gneiss, and mica schists.

The Residual Fauna

The dead rivers have a souvenir not only in the relief they have sculptured: one must look back to the period in which they flowed to explain certain peculiarities in the fauna.

It is well known that two thousand years ago Carthage employed elephants in its wars against Rome. They were captured in the basin of the great shotts south of Biskra, today dotted with palm groves. The depression of the great shotts is the zone of deposition of the Igharghar. Evidently the elephant had passed from the tropical savanas of central Africa to the borders of the Mediterranean by following the then living rivers of the Ahaggar. This is historical testimony. A living witness may be seen in the towns of Tunisia, where snake charmers will make the cobra dance for the tourist. The famous Hindu serpent is a tropical beast; it is also found in Egypt.

[15] Chudeau, *op. cit., passim;* Bourcart, *op. cit.*, p. 388; E. F. Gautier: Déserts comparés, Amérique et Afrique, *Ann. de Géogr.*, Vol. 34, 1925, pp. 146–162; reference on p. 162.

where the Nile explains its presence; in the depression of the great shotts it is today an absurdity, an anachronism.

In this depression tropical and Nilotic fishes unknown in Algeria and Europe—the chromis and the *Clarias lazera* (catfish)—have lately been found, a discovery that caused much surprise. They lie in the mud at the bottom of water holes and in the subterranean waters that feed the artesian wells.

At the other extremity of the Igharghar, at its head in the Kudia, Kilian reports on the other hand a Mediterranean fauna that has come from the north. These are the barbels and frogs in the water holes and the rare threads of running water.

But the most extraordinary case is that of the crocodile. A little colony has been discovered in the heart of the desert in the water holes of the sandstone plateaus. Paradoxical as is this fact, it is indubitable. A specimen has been brought to the laboratories. At latest reports, shameful to say, the French non-commissioned officers of the meharists were hunting the poor creature with the rifle.

This is what the zoölogist calls a relict fauna. These paradoxical beasts have all the characteristics, in particular degeneracy. The crocodiles do not exceed a meter in length, the catfish two centimeters. The cobra seems to have kept its proportions, but this reptile, so formidable in the Indies, is a languid and inoffensive creature in the Sahara.

The wadis have been dead since the end of the Quaternary, it would seem; but a certain number of the animals that peopled them still live, by a miracle, without doubt, and in diminishing number; but they live. The geologists date back the end of the Quaternary some thousands of years, an indefinite but lengthy period of time. Could the relict fauna of the rivers of the Ahaggar survive such a lapse of time? Has the Saharan crocodile lingered 10,000 or 20,000 years at the bottom of his little pool? It is evidently possible, such is the marvelous tenacity of life and its power of adaptation to new conditions.

This brings us back again to the question of more recent change. As we have seen in the earlier part of this paper, the human element seems to show characteristics analogous to the relict fauna. The tomb of Tin Hinan indicates wealth and resources far beyond the present-day population.

Must we then conclude that a thousand years ago the Ahaggar was more humid than today and supported a denser population? That hypothesis perhaps is not necessary. The Ahaggar, as we have said, bear the name of the famous Hoouara whose exploits were noised throughout Barbary in the Middle Ages. It founded in Morocco the great dynasty of the Almoravides which conquered Spain and shook all the western Mediterranean. This far-flung dominion, this active

intervention in the affairs of Barbary necessarily had its repercussion in the fortunes of the central Sahara before the Arab invasions which drove the nomad Berbers to the Sahara.

It is true that such a historical explanation merely defers the difficulty. One may properly ask how it happens that the Veiled Ones, if they have always been as we see them today, could ever play so important a political rôle. This is for consideration elsewhere. However, one cannot help thinking of the Saharan crocodile.

The existence of the Sahara for many thousands of years is historically attested. In the Middle Ages it was almost as we now know it. But at "almost" we cannot lightly dismiss the question of change. In such a country the slightest trend towards deterioration may entail serious human consequences, a slow and progressive deterioration. Herein is the enigma.

WATER CONSERVATION IN SARDINIA

Marcello Vinelli

GEOGRAPHICAL environment has been hostile to Sardinian prosperity.[1] Position, climate, relief, hydrography, and geology have all combined to retard the island's progress. A possible means of escape from the tyranny of nature seems to be offered through the construction of great artificial reservoirs.

Sardinia is farther from the continent than any other Mediterranean island. Not only are contacts with the civil life of Italy thereby rendered more difficult and costly, but heavy transportation charges raise the prices of all imported and exported products. The Sardinian mountains turn their steepest slopes toward the Tyrrhenian Sea and Italian mainland. The rough, wild, menacing ranges of Gallura and Barbagia, with their precipitous crags, tower directly over a harborless eastern coast. Though the western coast is bordered by extensive, low-lying, more or less fertile plains and hill country and has a number of ports, it is far removed from Italy proper.

The Rainfall

From observations taken at the rainfall station at Cagliari between 1856 and 1916 sufficient data have been gathered to enable us to arrive at certain generalizations concerning the rainfall of Sardinia. Table I shows the mean monthly and annual rainfall at Cagliari, at Sassari in the northwestern part of the island (altitude 225 meters; 27 years of observations), and at Catania in Sicily (35 years). Although the summer rains at Cagliari are in quantity equal to those of Catania, in the latter place there is somewhat more rain during the months following the summer. The engineer Omodeo, therefore, does not exaggerate when he asserts that from the point of view of agricultural meteorology, the region of Campidano in Sardinia is the least favored of the entire kingdom. Even Foggia itself in "dry Apulia," which receives the minimum precipitation of continental Italy, enjoys a far more favorable seasonal distribution than that of Cagliari. The rainfall between April and September at Foggia amounts to 198 mm. as compared with only 124 mm. at Cagliari.

The irregularity of precipitation in Sardinia is evident when we compare the two extremes, a maximum of 860 mm. (34 inches) and

[1]For a study of the physiography of Sardinia in relation to settlement and economic life see Erwin Scheu: Sardinien: Landeskundliche Beiträge, *Mitt. Gesell. für Erdkunde zu Leipzig 1919–1922*, Leipzig, 1923, pp. 32–102.

a minimum of 133 mm. (5 inches). The latter altogether exceptional minimum was that of 1913 in which year the rainfall was distributed over only 50 days. On rainy days the downfall is usually intense and torrential. The rainfall régime of Sardinia is not paralleled elsewhere in Italy and is characteristic rather of truly desertic regions.

TABLE I—MEAN MONTHLY AND ANNUAL RAINFALL IN SARDINIA

(*In millimeters*)

PLACE	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
Cagliari	46.6	40.7	50.2	38.2	29.7	18.4	3.2	5.9	28.6	55.7	66.6	51.8	435.06
Sassari	66	46	51	61	45	25	5	12	39	86	92	75	603
Catania	83	57	51	34	17	7	2	9	31	66	90	86	533

The mean monthly temperature during the dry season is very high, and evaporation is excessive owing to the frequent winds. Herbaceous plants tend to die in the hot summer, and the life of the trees themselves becomes dormant.

RELIEF, FORESTS, AND STREAMS

Although there are no very high peaks, Sardinia is distinctly mountainous. The highest summit, Gennargentu, falls just short of 1920 meters. The mountains are not lofty enough either to exert a notable influence on the precipitation or to permit the storage of water in the form of perpetual ice and snow, which by melting might serve to feed perennial streams.

With the mountains of Corsica, those of Sardinia constitute a group quite distinct from the Apennines and Alps. The Sardinian mountains have numerous ramifications and are deeply cut into by ravines and winding valleys. Though picturesque, economically they are unfavorable to man, lacking the broad lengthwise and crosswise valleys characteristic of the Alps, where they support relatively dense populations on their ample floors. A glance at a topographical map of Sardinia reveals the paucity of level, open zones traversed by large watercourses. So split up are the mountains into small, steep chains and ridges that they are but poorly adapted to farming. Frequent gullies and ravines make communication difficult. Under these disadvantageous conditions the growth of centers of economic activity is almost impossible.

The people in many of the Sardinian communes dwell upon the hillsides and crests, whence they look down upon the watercourses below, dry or nearly dry in summer, wild and roaring during the brief rainy season. Economic unity is hard to attain in such a region.

Nor are the natural conditions bettered by the activities of man

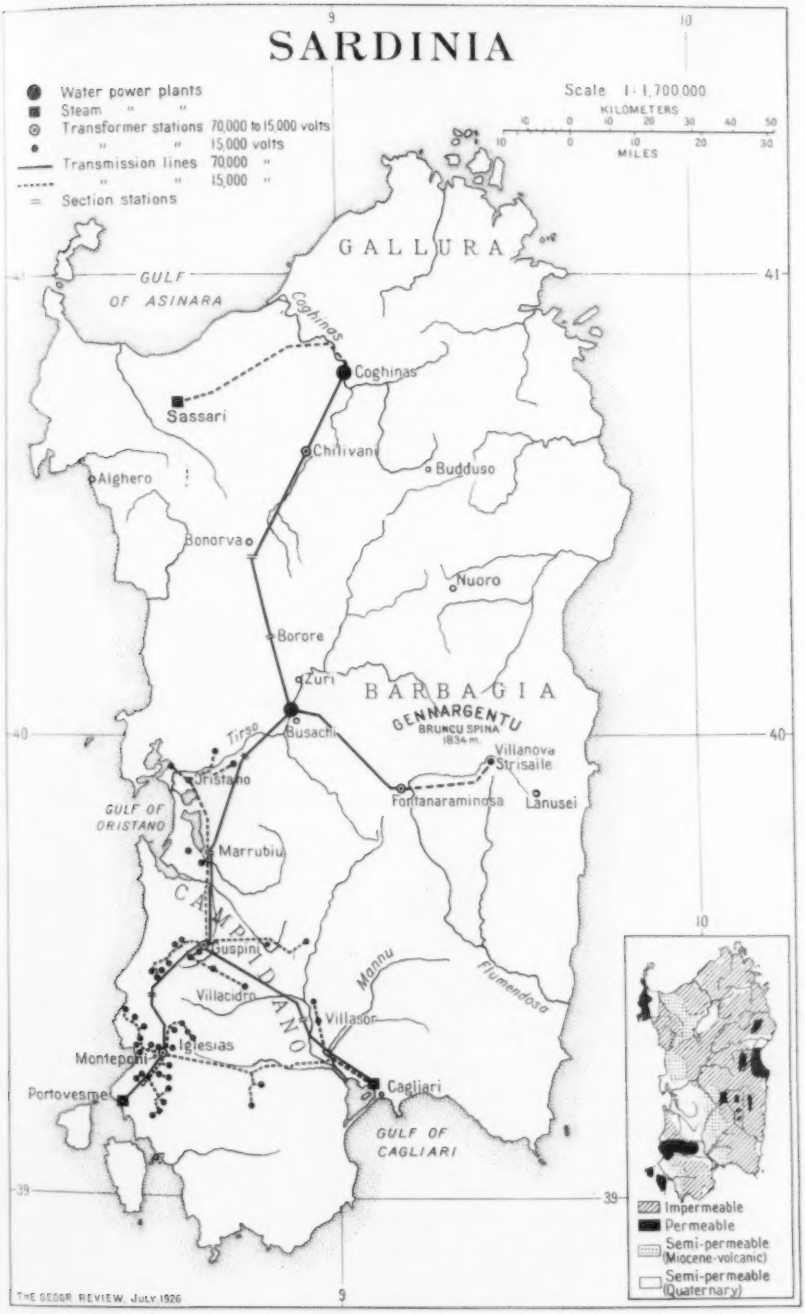

FIG. 1—Map of Sardinia showing water-power development. The Tirso project is completed, that of the Coghinas is under construction, and that of the Flumendosa is under consideration. Inset character of the terrain in relation to water conservation: compare with Table II.

himself. Great wooded tracts have been devastated by unintelligent deforestation. Attempts at reforestation have encountered enormous difficulties owing to the lack of foresightedness on the part both of people and government. The quality of the rocks, resistant to weathering and decomposition; the poverty of the vegetation and its complete absence on some of the steepest slopes; the hot, dry, rainless summers and windy winters—a climate inimical to small plant life; the abandonment of the greater part of the soil to the simplest sort of pasturage with all the attendant abuses of an industry intolerant of restriction or discipline; and finally, insufficient financial means: these are all independent and insuperable obstacles to reforestation. When we understand them we are confirmed in our view that the forests of Sardinia do not exert any appreciable influence on stream flow at the present time and that not much may be expected of them in this respect for a long while to come.

The plains of Sardinia are of limited extent. As one goes from the coast into the interior, they succeed one another ranging from marshy and malarial lowlands near the sea to high and dry plateaus. The largest plain is that of Campidano in the southwestern part of the island. On the whole, the relief does not favor agriculture either in the mountains or on the plains.

Nor does the hydrography of Sardinia make up for the disadvantages of the relief. The watercourses can scarcely be said to have any definite régimes. Their periods are extremely irregular. Full and swirling, occasionally bringing ruin and disaster in the brief winter season, the waters virtually disappear during spring, summer, and most of the autumn. Then the channels are transformed into unhealthy swamps; or frequently the streams go dry altogether, leaving only melancholy traces of water in the deepest hollows. Moreover, the torrential character of the Sardinian rivers has been growing more marked during the last century. There has been a progressive lowering of the average water levels, and, conversely, floods have occurred of a violence previously unknown. This has resulted partly from the destruction of the forests by man and fire and partly from the extensive cultivation of steeply sloping fields which would have been left alone under a well-understood agricultural and social policy.

The water power of the island cannot be directly harnessed for industrial purposes owing to the torrential character of the streams. Extensive modifications of the stream flow are necessary, as otherwise no power would be available during at least a half of each year. Nor are the streams of any use for the transportation of human beings and freight, or for the floating of timber. They are an obstacle to communication. They hamper the construction of works of public utility and threaten those already completed.

Permeability of the Ground and Run-off of Water

The engineer Omodeo has divided Sardinia from the point of view of the permeability of the ground, into four areal categories (Fig. 1). These are:

Impermeable terrains	14,500	square kilometers	(60%)
Permeable terrains	2,000	" "	(8%)
Semi-permeable terrains (Miocene-volcanic)	4,300	" "	(18%)
Semi-permeable terrains (Quaternary)	3,290	" "	(14%)

The impermeable areas, it is seen, cover the greater part of the island.

The permeable areas, though they are made up of terrains of very different geological ages and are scattered widely throughout Sardinia, are limited in their total extent. The most permeable areas are the smallest of all, covering hardly more than 150 square kilometers. The rain water falling upon these tracts for the most part disappears into the ground, offering no hope of its recovery for utilization.

The semi-permeable areas occupy 32 per cent of the total surface of the island and constitute the best agricultural lands, because of the physical and chemical composition and the thickness of their soils and because these tracts tend to be level.

On the basis of combined meteorological and hydrographical observations, it has been possible to determine the coefficient of loss of precipitation for each of the four types of area. These are shown in Table II.

Table II—Precipitation Loss in Sardinia

Formation	Area in Square Kilometers	Rainfall in Bileions of Cubic Meters	Loss in Billions of Cubic Meters	Percentage of Loss
Impermeable	14,500	10.09	6.13	56
Permeable	2,000	1.2	0.84	70
Semi-permeable (Miocene-volcanic)	4,300	2.4	0.60	25
Semi-permeable (Quaternary)	3,290	1.5	0.22	15
Totals	24,090	16.5	7.89	49

The Enterprise Undertaken by the State

The problem which the Italian government has undertaken to solve is that of storing up the excessive and destructive run-off caused by the great winter rains in such a way that it may be converted into

a continuous run-off, constant throughout the year. In order to accomplish this the government is undertaking the construction of a series of great artificial reservoirs.

Studies carried out by engineers have shown that of all parts of Italy Sardinia is best adapted to the establishment of such reservoirs. Relief, geological structure, and the character and course of the streams combine to produce numerous basins which are easily converted into lakes because of their position and levels and because of the impermeability of the ground. Materials for use in constructive operations are also readily available. All this makes it possible to build dams and dikes at a low cost.

FIG. 2—The Tirso dam during the course of construction.

The basic geological formations, consisting of ancient granites and schists, impermeable, resistant, and compact, although they may favor the useless run-off of the rain waters, are distinctly advantageous from the point of view of measures to be taken for its conservation. This is evident when we compare the situation in Sardinia with that in the Muro Lucano basin of Basilicata. In the latter, after the water has reached a certain level owing to the permeability of the ground, it will rise no higher. No amount of investigation has served to reveal the subterranean course which it takes. In the Tirso basin of Sardinia, on the other hand, a basin which occupies a very extensive area, the coefficient of loss through subterranean channels is almost zero.

The valleys of the Sardinian rivers, such as the Tirso, Coghinas, Flumendosa, Mannu, Temo, and Cedrino, are alternately broad and deeply incised according as the rocks vary in hardness. This favors

the impounding of lakes in the basins formed on the softer rocks. Omodeo has shown that under favorable technical and economic conditions more than 500,000,000 kilowatts (the equivalent of 580 per inhabitant) might be produced by the water power derived from the outflow of such lakes. This is twice as much power in proportion to the population as that developed in Lombardy, the most highly industrialized part of all Italy.

FIG. 3—The great lake created by the impounding of the waters of the Tirso.

Three great hydro-electric projects are to mark the beginnings of a proposed transformation of Sardinian economic life. The first, that of the Tirso, is completed; the second, that of the Coghinas, is under construction; the third, that of the Flumendosa, is still on paper.

The Tirso River rises in the granitic plateau of Buddoso in the northern part of the island; thence it flows south and then west into the Gulf of Oristano, thus dividing the island diagonally into two almost equal parts. The basin of this stream receives a mean annual precipitation of seven hundred millimeters. Active operations on the Tirso, begun in 1919, were completed in 1922. They have involved the building of two dams with hydro-electric power stations, one at Santa Chiara di Ula (Fig. 2) and one near the bridge of Busachi. The former collects water derived from a catchment basin of more than 2000 square kilometers in an artificial lake twenty-five kilometers long by two wide, with a surface of fifty square kilometers and a capacity of 416,000,000 cubic meters. The latter produces a reser-

voir of about 2,000,000 cubic meters capacity. The formation of the larger lake has submerged the old village of Zuri, the population of which has been dispersed partly into the neighboring communes and partly into a new village built at a higher level. The new village church, a structure of considerable artistic beauty, was constructed out of the materials of the old church.

The operations on the Coghinas in southern Sardinia are on a smaller scale. An artificial lake will be formed with a surface of about 1800 square kilometers and a capacity of 254,000,000 cubic meters. The plant on the Coghinas will be united electrically with that on the Tirso in such a way that the one may supplement the other in case of need. It is expected that the Coghinas enterprise will be completed in 1926.

The Flumendosa project will be of even greater importance than the other two.

To no other region than Sardinia are the words of Besnard more appropriate: "a garden with water, without water a desert." The reservoirs already finished and proposed are intended to liberate from desertic conditions a region situated in the very heart of the Mediterranean. They are intended to conserve and discipline what are unquestionably very great hydraulic resources. They are intended to do away with the many existing evils. The work should not only bring about a positive economic advance but a veritable revolution, especially in so far as the problem of the eradication of malaria is concerned.

NOTES ON THE PHYSIOGRAPHY OF HONDURAS

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TO the outside world "Honduras" might well mean the narrow strip of coastal plain bordering the Caribbean. This is the banana country; and, speaking in round numbers, 70 per cent of Honduran export trade in recent years has been in bananas. Yet the area given to the great plantations is only a small part of the whole country. The coastal plains of Honduras, shown in dashed ruling on the map, Figure 1, and including the small patch on the Pacific, make up only 10 per cent of the area. Still more striking are the facts when the distribution of the banana industry is examined more closely. It is practically all west of Trujillo, the eastern part of the plain not being developed to any extent. A brief physiographic examination is illuminating.

The Caribbean Coastal Plain

From the Guatemalan border to beyond the mouth of the Black River, a distance of nearly three hundred miles, mountains rise abruptly from the sea to altitudes of from 1500 to more than 5000 feet. At their bases the outwash of silts, sands, and gravels has formed a narrow plain, varying in width from a few rods to about twelve or fifteen miles, where embayments have given rise to plains of unusual extent. Along the larger rivers entering the Caribbean, broad alluvial plains merge with the coastal plain proper; and the coastal climatic conditions are thus carried relatively far into the interior. The most notable examples of such alluvial plains are found in the valleys of the Motagua, the Ulua-Chamelecon, the Colorado, and the Aguan Rivers. For the most part these plains are no longer subject to overflow. Field evidence indicates that the alluvial plains referred to now occupy terrace positions and that since their deposition it is probable that a slight elevation has occurred which has raised them out of flood danger. It appears, therefore, that the rather recent erosion conditions have been characterized by three distinct stages, namely: incision of deep valleys, when the general altitude of the land was somewhat higher than at present; lowering of the general level of the land and consequent decrease in the gradients of the streams, which produced deposition along the steep-walled valleys; slight elevation, again causing stream incision in the

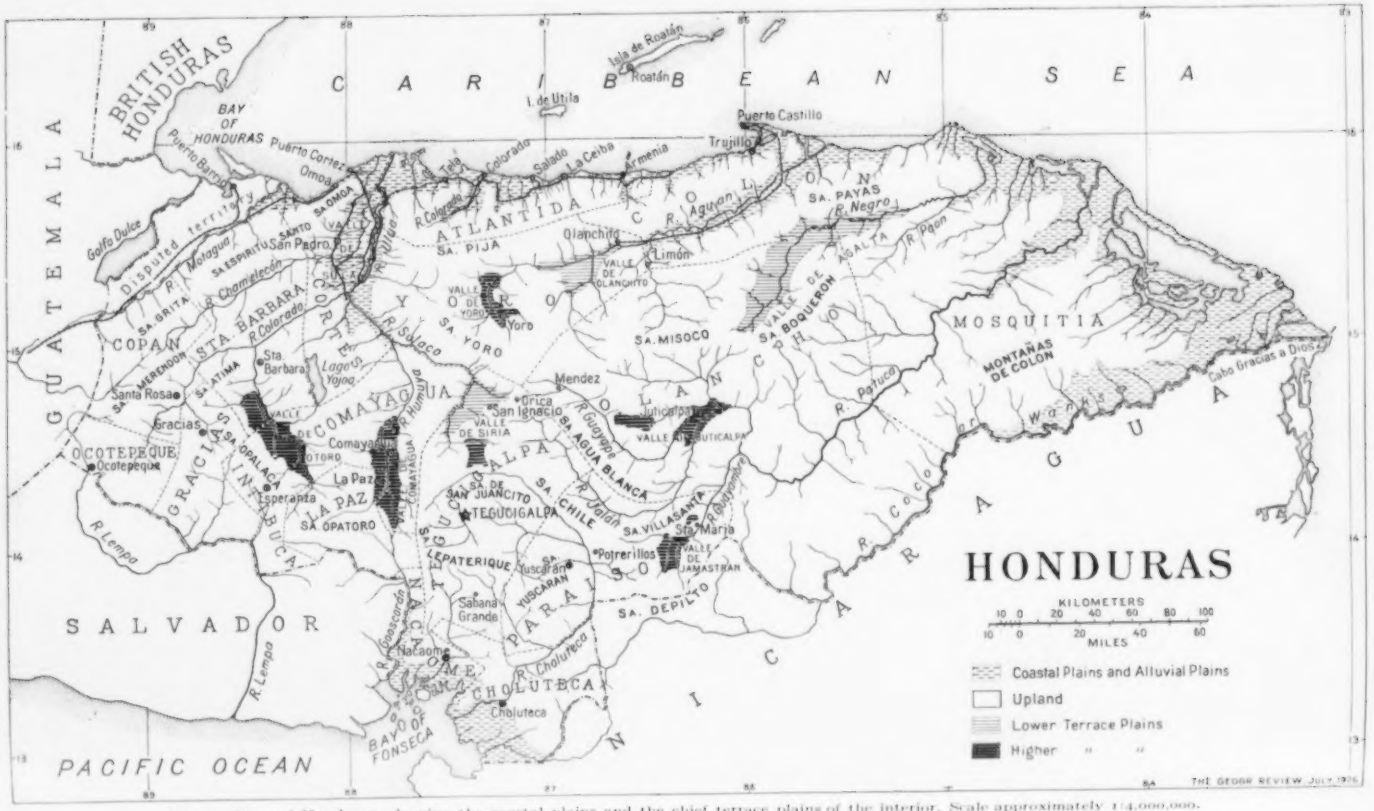


FIG. 1—Map of Honduras, showing the coastal plains and the chief terrace plains of the interior. Scale approximately 1:4,000,000.

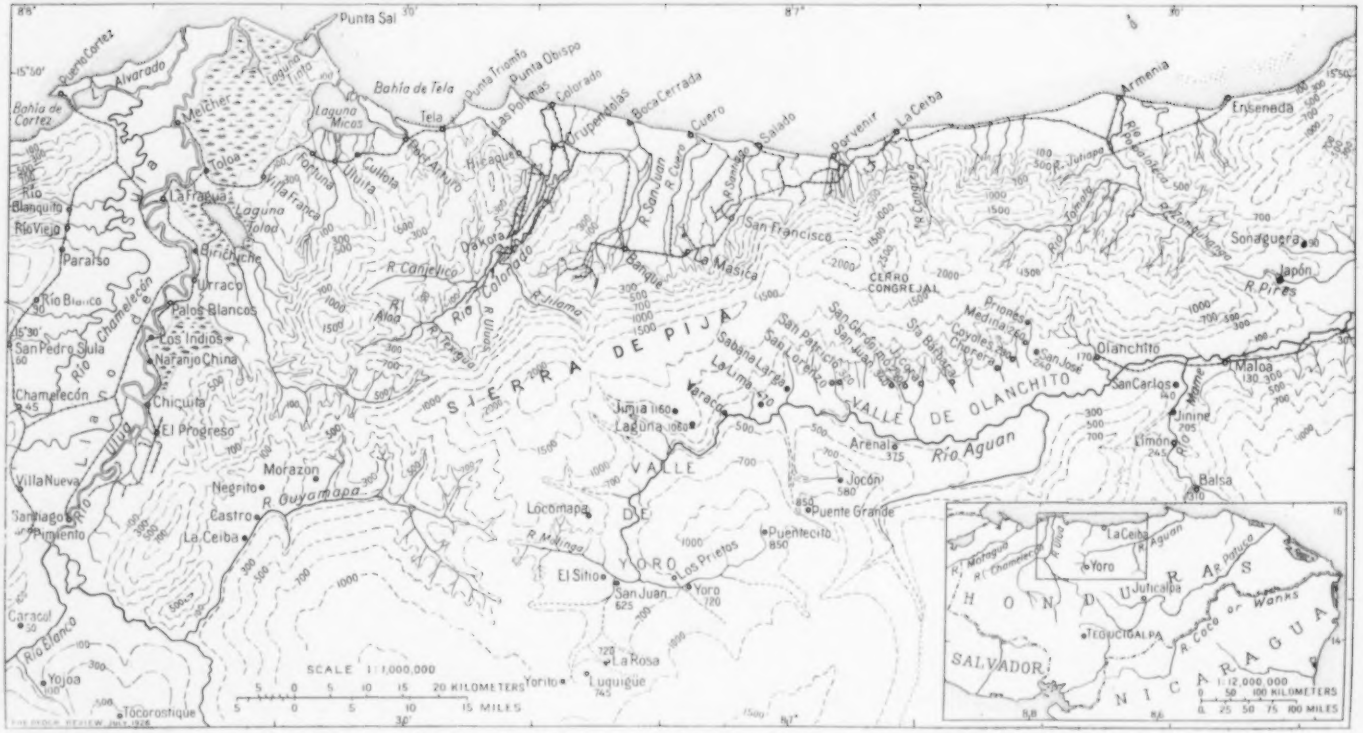
alluvial plains recently formed. This appears to be fairly conclusive in the case of the Colorado and the Aguan Rivers but is not a sufficient explanation for the broad lower courses of the Motagua and the Ulua-Chamelecon, where natural levees have been extraordinarily developed and are accompanied by the traditional poorly drained lands back some distance from the stream channels.

In eastern Honduras the streams of the coastal lowlands are not deeply incised below the flood plain. The lower courses are bordered by levees and hence in their general aspects resemble the Motagua and the Ulua of the western portion of the coast and differ rather markedly from the central part with its more deeply incised Colorado, Aguan, and Black Rivers. Thus it appears that there has been a more pronounced recent uplift and change of gradient of streams about the central part of Honduras than is true for either the eastern or the western portions of the north coast of the territory.

The soil of these plains is very fertile and is easily tilled, making it possible for banana plantations of long life to be developed there. The topography and soil fertility are among the essential factors that have enabled Honduras to become one of the greatest banana producing countries in the world and the foremost source of banana imports into the United States.

East of the mouth of Black River the mountains are farther from the coast. The plain reaches a width of forty or fifty miles near the Nicaraguan border. In this area the low interfluves between the rivers, marshes, and lagoons are generally covered by a gravelly mantle rock, which evidently was washed down from the mountains farther inland. This mantle rock has weathered into a shallow soil with coarse subsoil. Lagoons characterize the outer portion of the coastal plain in this area; and the streams have well defined natural levees in their lower courses, which upstream merge into flood plains quite well developed and apparently out of flood danger. Recent uplift has evidently been very slight and not sufficient to produce a well drained condition of the plain. The shallow sandy soil with its coarse texture and gravelly subsoil has been so thoroughly leached by the heavy rainfall of the area that it is incapable of sustaining any heavy growth of vegetation, and thus the broad low-lying uplands present a prairie-like appearance. This is the coastal section of the Mosquitia territory, a country of very gentle relief, heavy rainfall (said to vary from 120 to 200 inches a year), grassy plains, low productivity, and a sparse population. The Indians of the district live in small villages along the stream courses, where the soil is deeper and richer and foodstuffs production therefore possible. The food of the Indians consists very largely of fish, rice, cassava, and bananas. In some cases, where a native village has found a favorable site for fishing and hunting, its inhabitants go in their canoes (*pit-pans*) twelve to fifteen

Fig. 1—Map of Honduras, showing the coastal plains and the chief terrace plains of the interior. Scale approximately 1:4,000,000.


Punta Sal
Bahía de Cortez
Bahía de Tela
Tela
Laguna Micos
Laguna Tolo
Toloa
La Fraguna
Río Blanquito
Río Viejo
Paraíso
Río Blanco
Palos Blancos
Los Indios
San Pedro Sula
Naranjo China
Chamelecón
Chicuta
El Progreso
Villa Nueva
Santiago
Pimiento
Caracol
Río Blanco
Yojoa
Tocorostique
Morazón
Negrito
Castro
La Ceiba
Río Ulúa
Río Chamelecón
Río Motagua
Río Guayamapa
Río Aguán
Río Patuca
Río Coco or Wanks
Río Tinto
Río Paulaya
Río Juticalpa
Río Sico
Río Platano
Río Mocorón
Río Warunta
Río Kruta
Río Wampú
Río Segovia
Río Negro
Río Coco
Río Wawa
Río Prinzapolka
Río Grande
Río Escondido
Río Kurinwas
Río Mico
Río Kukalaya
Río Kama
Río Kukra
Río Indio
Río Maíz
Río Punta Gorda
Río Brus Laguna
Río Patuca
Río Guayape
Río Jalán
Río Sulaco
Río Yoro
Río Ocotal
Río Humuya
Río Ulúa
Río Jesús
Río Chamelecón
Río Blanco
Río Aguán

miles inland to find suitable soil for the production of their staple breadstuffs—bananas and *platanos*.

The industrial development of the Caribbean coastal plain of Honduras may therefore be said to have progressed through the best drained and most fertile part of the region. The eastern part, though of greater extent, is not well drained, is less fertile, and so far has not felt to any great extent the magic touch of development programs financed by foreign capital.

The Pacific Coastal Plain

The Pacific coastal plain consists of a relatively small area bordering the Bay of Fonseca. That subsidence, probably in late geologic times, gave rise to the Bay of Fonseca is indicated in the broad estuaries of the streams and by the extensive embayments projecting into the coastal plain. These estuaries and embayments are bordered by tidal marshes and mangrove jungles. The islands in the Bay of Fonseca and the mountains that rise abruptly out of the coastal plain are largely of volcanic origin, members of the same general group that extends from Guatemala across Salvador and through Honduras into Nicaragua. None are active in Honduras; but across the bay in Salvador smoke may frequently be seen issuing from one or two well-known craters, reminding the observer that he is in the land where earth's fires are still smoldering.

The Sierra Region

The Sierra region is characterized by short mountain ranges separated by deep structural basins into which canyon-like valleys and intricately ramifying tributary systems have been incised. According to Sapper[1] the highest altitudes, exceeding 8000 feet, are reached in Gracias in the west. The San Juancito mountains north of Tegucigalpa attain an altitude of 7500 feet.[2] These are part of what may be termed the Southern Cordilleras, which constitute the chain of greatest relief connecting with the Yuscaran Mountains and with the Sierra de Depilto toward Nicaragua and with the Opalaca Range toward Guatemala. Along the north coast is a series known as the Sierra de Omoa, Sierra de Pija, and Sierra de Payas, which should be classified together because of their topographic continuity even though structural unity may be wanting; and hence for them the term Northern Cordilleras is suggested. Between the two major groups of mountains thus named are several important transverse

[1] Karl Sapper: Beiträge zur physischen Geographie von Honduras, *Zeitschr. der Gesell. für Erdkunde zu Berlin*, 1902, pp. 33–56, 143–164, and 231–241.

[2] J. H. Sinclair: Notes on the Mapping of an Area in Southern Honduras, *Geogr. Rev.*, Vol. 14, 1924, pp. 275–281.

FIG. 3

FIG. 4

FIG. 5

FIG. 3—Harbor of La Ceiba, a large banana-shipping port. Cloud-banked mountains rise abruptly from a narrow coastal plain. (Photograph by Williams.)

FIG. 4—Another view in La Ceiba. (Photograph by Williams.)

FIG. 5—La Limón. Typical home and topography on well watered low terrace, Aguan basin.

FIG. 6

FIG. 7

FIG. 8

FIG. 6—Santa Maria Terrace, Guayambre River, looking west. Monadnocks of igneous rock protruding through the young sediments of the terrace plain.

FIG. 7—Orica, on a headwater stream of the Guayape. Houses in high altitudes have heavy walls, plastered on the outside, with tile roofs; only a few have windows.

FIG. 8—A typical "ridge-road" view; between San Ignacio and Orica. The roads in interior Honduras are mostly mule trails, and in the rougher sections ridges offer the most accessible natural highways.

ranges, which cause the whole interior to be a region of great relief. The popular statement that Honduras is the most mountainous of the Central American countries is not far from the truth.

Two Peneplains

The intermontane uplands are characterized by two high-lying peneplains, especially well shown in the southern half of the Sierra region. The altitudes vary considerably, but the differences between the two peneplains are generally from 700 to 1000 feet. The upper peneplain lies at altitudes of 3300 to 4500 feet, the lower one at 2500 to 3000 feet. The area in the vicinity of Yuscaran is typical of the topography noted in many places. Yuscaran lies about 3300 feet above sea level on the edge of the upper peneplain, which there extends in a general north-south direction. To the west of it rise rugged peaks of the Yuscaran Mountains to altitudes of 6000 feet or more. At the eastern front of this high peneplain there is an almost sheer drop of 800 feet to a lower peneplain into which the gorge of the Choluteca has been incised. This lower plain reaches widths of 5 to 6 miles on each side of the Choluteca, the gorge of which is from 500 to 600 feet deep. The village of Potrerillos is located on the eastern margin of the lower plain; and immediately back of the village rises the front of the higher plain, which corresponds in position, altitude, and topography to the plain of Yuscaran. Still farther east rise the knobs of the Villasanta Range to altitudes of 4000 to 4500 feet. Prominent features of both peneplains are the residual monadnocks that rise above the general levels. On the lower peneplain these residual hills are from 50 to 100 feet high, whereas on the upper peneplain the monadnocks rise to heights of 250 to 300 feet above the general level.

The flats of the upper peneplains are so pronounced, and the soil has been so little disturbed, that they are the places of maximum agricultural development. The people of Potrerillos, for example, raise their maize and other grains on the remnants of these high peneplains lying 800 feet above the town and so difficult of access that they can be reached only by tortuous mule paths.

The high-lying peneplains, while perhaps most vividly shown in the Yuscaran-Potrerillos district, are readily recognized in the greater part of the Sierra region. The upper one forms the prominent plateau from which the San Juancito and the Opalaca Mountains rise to the greatest altitudes found in Honduras. The lower one is clearly shown in the flat-topped, terrace-like forms that are conspicuous features of the landscape between Tegucigalpa and Sabana Grande. These uplifted peneplains are by no means areas of gentle relief. The upper one has been so severely dissected that in some places it is evidenced

only by the even sky line formed by the crests of its ridges, while elsewhere are narrow but flat interfluves separated by deeply incised gorges, the erosional development having nearly reached the mature stage. The relief is so great as to be distinctly mountainous in aspect. The lower peneplain has suffered less erosion. The valleys are for the most part very steep-sided, many of them being true gorges, and relatively flat interfluves are not uncommon. The erosional development may be classified as still in the youthful stage, although quite well advanced in it. The resultant topography is one that constitutes a serious barrier to the development of modern transportation facilities. Through much of the Sierra region the streams are still actively incising their channels, flood plains are wanting, the gorges are subject to heavy, raging floods, and the peneplains, although out of flood danger, have been so dissected that to cross them with railroads or even with automobile highways will involve a tremendous amount of grading and bridge building.

Two Terrace Levels

The streams of the Sierra region for the most part flow in canyons. In many places, however, they are bordered by terraces of which there appear to be two distinct and persistent levels—the upper from 2000 to 2400 feet, the lower from 300 to 1000 feet above sea level (Fig. 1). The upper system is represented by a number of relatively high-lying interior plains some of which are quite extensive and are referred to by the natives as *plancitos*. These are remnants of terraces formed, it appears, either when the general land level was lower than the present or before erosion had incised into the upland sufficiently to drain the high structural valleys there existing. The most prominent of these terrace plains are Valle de Comayagua, altitude 2100 feet; the plain of Talanga, altitude about 2300 feet; the plain of Jamastran near the headwaters of the Guayambre River, altitude 2000 feet, and the Valle de Otoro, altitude approximately 1800 feet. These, together with several smaller terraces located at about the same altitude and in similar positions, all appear to belong to the same system.[3]

The Valle de Comayagua is the largest of these terrace plains, having a length of over 30 miles and reaching a maximum width of ten miles. The plain is covered with sand, gravel, and boulders, mixed with finer materials; and into this surface débris the streams have only cut shallow channels. To the south the Comayagua plain terminates in a greatly dissected topography in which is the gorge of the upper Goascorán River, which descends rapidly to its lower, graded course

[3] Altitudes were determined by means of aneroid barometers and are therefore only approximately correct.

leading into the Bay of Fonseca. Northward a similar steep descent is made by the Humuya River to its junction with the Sulaco, beyond which is the broad and gently sloping Sula valley. This combination makes a relatively easy transcontinental route, a route which has long been in prospect as the natural location for an interoceanic railroad. In connection with some of the streams leading from the high terrace plains, true alluvial terraces of two levels are distinguishable. This feature is especially well shown along the Guayape, Jalán, and Guayambre valleys.

The conditions at Mendez are typical of what may be observed in many places along the valleys mentioned. Mendez is located on a terrace in the upper Guayape valley at an altitude of 2400 feet. The gorge of the Guayape is about 150 feet deep. About 40 feet above the Mendez flat appear mesa-like remnants of the highest terrace level: hence the field evidence shows that at the highest stage of valley filling the floor was at least 150–200 feet higher than at present, and there was built a system of alluvial fans and flood plain. Then this old valley floor was lowered by erosion about 40 feet, and most of the upper level was removed, leaving only patches of terrace along the valley sides and some mesa-like remnants standing above the level of the lower terrace into which the stream at the present period of renewed cutting power has incised its channel.

Another instance of a well preserved terrace remnant is found at Santa Maria in the upper Guayambre valley about 15 miles below Palmira. This terrace is about three miles long and a mile wide, sloping eastward at the rate of about 40 feet a mile. The surface is flat except for a few protruding bed-rock monadnocks. Gorges more than 100 feet deep have been cut into it by tributaries of the Guayambre along the contacts with the mountains, but the central part remains a flat, undissected interfluve. This terrace clearly belongs to the same level as the Jamastran plain, farther upstream, and its slope eastward indicates that the high terrace forming the well-known Juticalpa plains belongs to the same series although its altitude is about 700 feet less.

These large terrace plains are for the most part open, nearly level tracts with a sandy or gravelly soil. The desert type of vegetation prevails, several cacti of tree size being the predominant forms. As may be inferred, they are areas of comparatively low rainfall since they are surrounded by mountains which rise 2000–3000 feet above them. The most dependable estimates available place the annual rainfall at from 30 to 60 inches. During several months of the year, from January to May, practically no rain falls there, and temperatures during the day are then quite high. The uneven distribution of rainfall is a serious handicap to agricultural development, for the dry season is so prolonged that vegetation becomes parched, streams go

dry, and supplies of water even for domestic use become scarce. To overcome this handicap establishment of reservoirs for storage of flood waters and the development of irrigation systems will be necessary.

The lower terrace previously referred to is represented by the Valle de Olanchito of the Yoro valley, the Valle de Agalta of the Black River valley, and the Valle de Siria of the Sulaco valley. These are all at levels intermediate between those of the high terraces previously described and those of the flood-plain lands bordering the Chamelecon, Ulua, Colorado, Aguan, and Patuca Rivers and appear to mark a different depositional stage. Along the larger streams, farther inland, appear small remnants of low terraces that are evidently part of this same intermediate series.

From the standpoint of physiography it is interesting, to say the least, to find two well differentiated terrace systems along the major stream courses as well as two distinct peneplains represented in the intermontane uplands. The gently sloping lands on the interfluves of the peneplains and the flat lands of the terraces are the areas of interior Honduras best adapted to agricultural development. Aside from scattered local strips of flood plain they are the only lands where the topography is conducive to permanent agriculture. Elsewhere slopes are mostly too steep to permit of stable soil if the forest cover should be destroyed. The percentage of undissected peneplain and terrace is great enough, however, to support a population several times as dense as that of the present.

These topographic features, peneplains and terraces, described above are best shown in the interior of the country. In the southern part recent volcanism has been effective in obscuring them, and in the north erosion caused by the steep gradient streams of the mountain fronts has been so effective that any evidence formerly existing there has been obliterated.

THE SOILS OF THE AMAZON BASIN IN RELATION TO AGRICULTURAL POSSIBILITIES

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THE prevailing idea of the Amazon Basin is that of a vast flat low-lying plain subject to annual inundation. "Man has invaded the region a little too early, and the best description that can be given of his invasion is that it is an indiscreet intrusion. . . . Numerous are the obstacles which he will have to overcome by way of compensation for his impertinence in trying to establish there his domain."[1] It is true that man will have to overcome many obstacles in his utilization of the Amazon Basin but not because of its extreme physiographic immaturity. The erroneousness of this idea is shown by the work of the Crude Rubber Survey,[2] which made a special study of soils and their topographical relations—a subject regarding which little information had heretofore been available. This paper will give the results of the work on soils, a previous paper in the *Geographical Review* having considered the topography.[3] Its bearing on land utilization will be illustrated by a preliminary discussion of the agricultural possibilities of the region as seen by the Survey.

Agricultural Possibilities

The value of any region measured in terms of its capacity to satisfy the material needs of mankind may be looked upon from two points of view—in its relation to a sessile and directly self-sustaining population and in its relation to the world as a whole and the world demand for commodities.

There can be no question about the capacity of the Amazon Basin to support a very great number of those peoples who are able to thrive on the ordinary tropical products. On a conservative estimate not less than 70 per cent of the Inner Amazon Basin, an area of over one million square miles, is capable of some form of agricultural de-

[1] Paul Le Cointe: L'Amazonie brésilienne: Le pays—ses habitants, ses ressources, notes et statistiques jusqu'en 1920 (2 vols., Paris, 1922), Vol. 1, p. 166.

[2] The Crude Rubber Survey was carried on by a special commission of the U. S. Department of Commerce in 1923–1924. The principal report on the Amazon Basin is "Rubber Production in the Amazon Valley," by W. L. Schurz and others, noted elsewhere in this number of the *Review*.

[3] C. F. Marbut and C. B. Manifold: The Topography of the Amazon Valley, *Geogr. Rev.*, Vol. 15, 1925, pp. 617–642.

velopment. This is an area about equal to that of ten states each as large as Missouri. A population living on tropical fruits, sugar, beans, rice, and manioc with beef of low grade could attain a high degree of density. The great size of the area makes the potential aggregate very large, though it is probable that the capacity, per unit area, is not so great as that of the Antillean group of islands or of a good deal of Central America. The soils are undoubtedly less productive, and it is probable that their productivity will be maintained with more difficulty. As yet the existing population is insignificant: the region may be described as practically unoccupied.

The value of the region as a producer of those products entering extensively into the world's commerce seems to be much less than its domestic maintenance value. In the discussion of such a question one cannot safely don the mantle of the prophet. We shall, however, assume that the products entering into this commerce in the near future will not be essentially different from those in demand at the present time.

The raw products making up the bulk of the world's commerce in such articles obtained through cultivation of the soil consist mainly of grains, sugar, cotton, live stock products, fibers other than cotton, vegetable oils, and in recent years, rubber. Certain products important in world trade when considered from the point of view of value are derived from areas relatively insignificant in extent. Thus it is with tropical fruits, spices, coffee, and cacao. It is extremely improbable, for instance, that bananas will ever be shipped from the Amazon valley to Europe or North America, since the demand for an indefinite period can be supplied to Europe from relatively near-by Africa and to Canada and the United States from near-by Central America, Mexico, and the Caribbean islands. Cacao is grown with success in the Amazon region, but conditions do not seem to be any more favorable than those in regions which are already producing on a large scale. In the Amazon, in fact, its relative importance seems to be decreasing. The problem to be considered here is not only the trade aspects of products but equally the utilization of the lands of the Inner Amazon Basin.

We turn first to that product of the region most in the public eye at the present moment—rubber.

Rubber and Sugar

The investigations carried out by the Rubber Commission showed a very definite relation between the character of the soil and the production of both a high quality and a large quantity of rubber per unit area. Whether this relation is that of cause and effect, or merely an accidental one need not be discussed here. The fact is

brought out in the report of the Commission wherein is clearly shown that the highest grade of wild rubber and the largest quantity per unit area are produced on those soils having well drained deep friable reddish or reddish yellow clay subsoils. Such lands are known to occur in two large areas in the valley. One of these may be described as the Beni-Purús-Juruá region including the Acre territory of Brazil, northern Bolivia, and eastern Peru and is covered by soil group No. 5 on the accompanying soil map, Figure 10 (pp. 436–437). The other area may be described as that of the Tapajóz and Xingú regions. It covers the plateau that lies along both sides of these rivers and between them, extending from a few miles south of the Amazon southward to an unknown distance, and seems to extend eastward possibly to the Tocantíns region. The region is covered by soil group No. 3 on the accompanying soil map.

The Amazon Basin presents the environmental conditions that are undoubtedly favorable to the successful growth of *Hevea brasiliensis* in almost unlimited amount. This fact alone, however, cannot be accepted as a justification for the investment of a large amount of capital in extensive planting. The matter has been fully discussed in the report of the Rubber Commission cited above.

There seems to be no doubt that the climate of the Amazon region is favorable to the production of sugar. It is grown on a small scale throughout the region and on casual inspection seems to do well. Cultivation on a large scale would seem to depend on cost of production. An important factor in this case is the relative productivity of the soils in the Amazon region and in the regions where the commercial crop is now grown. Recent studies have given us some knowledge of the character of the soils in Cuba, in Brazil outside of the Amazon region, and in Hawaii. It is now known that the soils on which the Cuban crop is grown are fundamentally highly productive and entirely different from the soils of the Amazon valley. They are heavy, friable, have a high content of organic matter and fair to good content of the mineral constituents usually present in productive soils.

The productivity of the alluvial lands of Louisiana where our own cane-sugar crop is grown is proverbial. The Hawaiian lands seem to be somewhat less productive than those of Cuba and Louisiana, but the industry is thoroughly established and well organized and has been competing with Cuba for many years. The industry is also well organized in Java, a heavy producer. On account of the cheapness of land, the relative ease of clearing, and the wonderful opportunity for cheap transportation by thousands of miles of navigable rivers, the production of sugar is destined to be an important industry in the Amazon region, but its growth will be slow. There is no "bonanza" in sugar growing on a large scale in the Amazon.

FIG. 1

FIG. 2

FIG. 3

FIG. 1—A cornfield northwest of Rio Branco, Acre Territory. (Photograph by C. F. Marbut.)
FIG. 2—Campos at Rio Branco, Acre Territory. (Photograph by C. F. Marbut.)
FIG. 3—Cotton on the Seiler estate, Madre de Dios River, Bolivia. (Photograph by C. F. Marbut.)

Cotton and Hard Fibers

For several years the world's demand for cotton has been insistent. A great deal of effort has been expended by organizations in England to promote its production throughout the world. The price has been high. The world demand is greater and probably more permanent than for most of the other possible products of the Amazon Basin. It is evident that climatic and topographic conditions in the Amazon are as favorable to its growth as in any other tropical region. The soils are very much like those of the southeastern American cotton states: they are just as well drained and even better in the respect that they are not so sandy. It seems practically certain, however, that the growth of cotton or any other crop, in anything like an intensive way, will be found possible only through the use of manures. Commercial fertilizers can be carried by cheap water transportation into all parts of the Amazon region. The crop can be shipped out in the same way also. A good supply of organic matter can probably be maintained in the Amazon soils more easily than in those of the southeastern United States because of their less sandy character, the more luxuriant growth of grasses, and the probably slower rates of exhaustion because of heavier texture. Natural conditions, in fact, would not place the Amazon valley at a disadvantage in competition with the United States. It will be apparent, however, in all this discussion that diseases and pests are being left out of consideration entirely. The fact that cotton growing is rather rapidly increasing in the upper part of the valley, in eastern Peru, is indicative of the possibilities. The soils and other natural conditions over a large area east of the Peruvian boundary are essentially like those in Peru.

"Hard" fibers can probably be grown on the well drained alluvial lands, but it is not probable that they can be grown on the uplands with great success on the same tract of land for any considerable period without the use of fertilizers. There is no probability that the region can compete with the present producing regions. Certainly the hard fibers cannot be profitably grown on any large proportion of the area of the valley. The soil requirements of the two or three most important plants producing hard fiber have not been definitely determined. There is a strong suggestion in the geological and climatic environment of Yucatan that the soil is inherently more productive than that of the Amazon valley and also that the climatic environment of the Amazon valley would not be favorable to the growth of the Yucatan type of plant.

The Manila hemp and jute both seem to require an environment somewhat like that of sugar cane—an abundance of moisture and a soil of high productivity such as that of the great river valleys of the world. The area of soils of this kind in the Amazon valley is relatively

small, being confined at present to the narrow *varzea marginal*, or natural levee strips along the river banks. These are all narrow. In the whole region a large total production is possible, but the total land area occupied will be small and its proportion to the area of the valley essentially insignificant.

FIG. 4

FIG. 5

FIG. 4—Kapok, or Sumauma, tree and Sapucaia (cream nut) trees, Bragança, Brazil. (Photograph by Bjorklund.)

FIG. 5—Rubber tree 4.35 meters in circumference, Campinas, 20 miles north of San Luis, Abuna River. (Photograph by Dr. Avelino de Oliveira.)

CORN AND RICE

Indian corn seems to cover a larger acreage than that of all other crops in the Amazon Basin. Stories are told of very high yields, but no detailed figures can be obtained. On the basis of appearances the experienced American corn-belt farmer would probably place the average yield at less than 20 bushels per acre. On the basis of soil character certain inferences may be drawn regarding the probable yield under good cultivation. As already noted, the Amazon soils aside from texture are much like those of the southeastern Coastal Plain in the United States. The average yields obtained on these soils in the United States, grown in a region where crops are well cultivated, thanks to habits inculcated by long familiarity with the

requirements of the cotton plant, and where the corn crop doubtless receives some residual effect from fertilizers applied to cotton crops previously grown on the same land, ranges around 17 bushels per acre. Allowing for somewhat higher productivity of the Amazon valley soils, it is very doubtful if the yields on good Amazon land and under good cultivation could be raised above 20 bushels except for a very few years after the land is brought under the plow, without the use of manures or long fallow periods.

It is now well known that the surplus corn of the world, the corn that enters the world's commerce, is produced on black lands and not on light-colored lands like those of the Amazon valley. It is probable, therefore, that the region will never become an important exporter of corn; but it is certain that its soils under careful management can produce all the corn likely to be needed for its own population for an indefinite time. Its corn production will have the same relation to its other agricultural industries as does the corn produced in our own cotton states—a crop for home use and not a money crop.

Rice is grown throughout the region in small fields and for home consumption only. The total production is not sufficient to supply the demand within the valley. The large cities import a considerable part of their requirements. It constitutes an important element in the food supply of the region, being consumed by all classes of the population.

Practically all the rice produced is grown without irrigation; and any development in the future, so far as can be seen at present, will be in the same direction except such as takes place on the alluvial lands. Irrigation of the uplands on a large scale cannot be established at any reasonable expense.

While the importance of the crop from the local standpoint is very great, there is no feature of topography, climate, or soils in the region that would give it any advantage over the regions that are now supplying the world's demand. The lack of upland soils especially adapted to irrigated rice growing and the uncontrolled annual flooding of the river valleys constitute disadvantages with which the Amazon valley would have to contend in any extensive rice growing for the world market.

Live Stock

The only important live stock industry of the tropics is that of raising cattle for beef and hides. It has flourished up to the present time mainly if not entirely on natural grasslands. There are no natural grasslands of any considerable size within the Inner Amazon Basin. Any industry that may develop in the future will have to be based on pastures made by clearing the tropical forests. It is well known that the soils of many regions which under natural conditions are not grassed but covered with dense timber will produce luxuriant

grasses if the forest be removed. It is also well known that when grass has become well established on such lands, even under natural conditions, it is able to maintain itself against the invasion of timber. The prairies of Illinois, Iowa, Minnesota, and Missouri cover potential timberlands.

Those who are familiar with the scant growth of grass on the Coastal Plain soils of the cotton belt of the United States will be inclined to question the possibility of establishing good artificial pastures in the Amazon valley when told that the soils are similar in many respects to those of the southeastern cotton states. The texture of a soil, however, seems to be of predominant importance in determining the success with which it will produce grass. Whatever the reason may be, the successful production of pastures in all parts of the Amazon region except on the sandy soils is evident to any traveler who cares to look into the matter. The grasses are not so nutritious and palatable perhaps as the best English and North American pasture grasses, but it has been clearly shown by examination of pastures in many places, mainly in the western and southwestern parts of the basin, that cattle may be raised and put into fair condition for slaughter. The grasses so far used are mainly native Brazilian varieties. They consist chiefly of three kinds, Capim Jaragua (*Andropogon rufus*), Capim Gordura (*Melinis minutiflora*), and Capim? (*Axonopus* sp?)—a near relative of the carpet grass of the cotton belt. In the United States the last-mentioned grass does well in moist places only, while in the Amazon valley it seems to do well everywhere.

The beef hitherto produced on these pastures cannot be ranked with that from American corn-fed cattle or from the pure-bred stock from Argentine pastures. The cattle are practically without exception long-horned scrubs or crosses between these and the Indian zebu. It is not known whether breeds from the north temperate zone can be introduced or not, but even if they cannot it is certain that the Amazon valley can produce large quantities of beef of fair to low quality measured by the American, British, and Argentine standards. This is one food product consumed by white men which may be produced in large quantities in the Amazon valley.

Timber and Nuts

On account of the extreme hardness and heaviness of Amazon valley woods, as well as the total lack, as in all tropical regions, of a pure stand of any one kind or species, lumbering cannot be considered an industry that will ever become important in the region.

Only a small part of the total Brazil-nut yield is harvested at the present time. This could be increased to a considerable but unknown extent, it seems, if the price should warrant it; but there is no sign of

this at present. A small industry could be created by planting orchards near the rivers, but the area so utilized would necessarily be small.

Oil nuts and seeds can apparently be produced in large quantity. That they can ever occupy a large area of the Amazon region is highly improbable.

Physical Features of the Region

We now turn to analysis of that factor in productivity to which the authors devoted special attention—the soils. The Inner Amazon Basin is a region strikingly uniform in all the factors that make up its physical character. Reference has already been made to the topographic factor described in the paper cited (see footnote 3). The general geological conditions are briefly described in the same paper. Here we shall summarize by saying that the whole of the basin described is underlain by unconsolidated sands, silts, and clays; that in the upper part of the basin, where it is wide, the deposits are fine in grain, consisting of silts, clays, fine and very fine sands. In the lower, or eastern, part of the basin, where it is narrow and bordered also by crystalline rocks, the deposits on the northern side of the river are relatively coarse, consisting of sands and sandy clays. On the south side of the river the lower bench is sandy, essentially identical with the deposits on the north side of the river; but the high plateau lying a short distance back from the river is underlain by fine-grained materials.

Fig. 6—The forest at Porvir on the Acre River, one day below Cobija. (Photograph by Dr. Avelino de Oliveira.)

The deposits along the south side of the Madeira River and on the Beni below Riberalta are sandy, much like those on the lower part of the river. It will be noticed that sandy deposits lie in close proximity to the outcrop of the crystalline rocks surrounding the Inner Basin.

The Rubber Commission attempted no systematic original climatic observations of its own, though a considerable amount of local information was collected. The reader is referred to the reports of the Commission and to Brazilian sources. For the purpose of this

paper it will be sufficient to state that the region is hot and humid and that throughout its whole extent there is a more or less well defined division of the year into a rainy season and a dry season. There is considerable variation from place to place in the sharpness of the division and in the dryness of the dry season. In the region surrounding the mouth of the Amazon the dry season is by no means rainless, and usually in the driest part of the season vegetation shows very little sign of suffering from lack of moisture. Rains are frequent but much less so than during the rainy season.

From the mouth of the Xingú westward to the mouth of the Purús the dry season seems to be more pronounced than around the mouth of the river. Rains are relatively rare, and the vegetation in August showed some evidence of deficient moisture. The upper part of the basin seems to be in a climatic situation more like that of the Pará region. In no part, however, is the moisture supply so deficient that crops cannot be grown with fair success at any time of the year.

FIG. 7—River bluff at São Francisco on the Purús River. (Photograph by C. F. Marbut.)

With the exception of small areas the region is, or was until cleared, covered with a dense tropical forest. A portion of the watershed between the Madeira and Purús Rivers extending along the Madeira from Humayta to a point opposite Porto Velho is covered by a bushy grassland. The width of the belt is unknown, but it is known to approach to within less than a hundred miles of Labrea on the Purús. It is interrupted by strips of forest and jungle along the streams. On the sandy lands on both sides of the lower river there are small areas of grasslands, and a considerable area lies on the island of Marajó. A few small grassland areas lie in the Acre territory southwest of Rio Branco.

KATZER'S WORK ON SOILS

As we have said, very little information regarding the soils of the Amazon Basin was available before the Crude Rubber Survey was

made. This fact is not surprising since such information as was available consisted of that collected by specialists in zoölogy, geology, or botany or by travelers and none of it by specialists in soils. It was impossible to determine whether the vegetation of the region was growing on well-developed soils, as defined by the soil specialist, or merely on freshly laid alluvium, receiving a layer of fresh material with each annual inundation.

Katzer[4] is the first student of the region to make any direct conscious effort at discussion of its soils. He makes no attempt to describe them but undertakes a statement of conditions which he considers to obtain and to have obtained in the region and which he says have determined the prevailing characteristics of the soils. The following quotation will show, with sufficient clearness, his point of view:

> In a region like that of the Amazon in which running water exercises so widespread and permanent an influence and where heavy downpours of rain, during a rainy season that continues unbroken for months, exercise their vigorous erosive activity, fully or normally developed residual soils (*eluviale Grundschuttböden*) must play a subordinate rôle relative to water-laid soils. The former are confined in their distribution to the surface of many plateaus, mesas, and hills since in such situations only can such soils maintain an existence, even in small bodies, against the rapidly percolating and running meteoric waters and the constant erosive action of the wind.

Eluviale Grundschuttböden, as defined by Richthofen, are essentially identical with what were formerly called in this country and other English speaking countries *residual soils*. The expression had a more direct reference to the disintegration of consolidated rocks than to the evolution of a soil from this disintegrated material. It therefore referred much less to actual soil evolution than to the accumulation of unconsolidated rock débris or, as it is now more accurately designated, *soil material* rather than to soil. Since there are no large areas of consolidated rocks in the Inner Amazon Basin, it is evident that residual soils, as Katzer defines them, must occupy an extremely small area and play an insignificant rôle.

It is now well known, however, that the geological process by which the soil material of any locality or region has been accumulated has very little to do with the character of the soil developed from it. It is well known that soils of the same fundamental character may be developed from parent materials accumulated by residual or disintegrating processes and by various processes of sedimentation. It is also well known that many different kinds of soils may be developed from materials accumulated by the same process and from the same kind of rock.

Katzer is equally in error when he describes the soils as water-laid or alluvial. This term is permissible in the description of soils

[4] Friedrich Katzer: Grundzüge der Geologie des unteren Amazonasgebietes, Leipzig, 1903, p. 63.

but only in extreme cases. It is permissible in designating the "infantile" soils of recently built-up alluvial plains like the soils of the Amazon flood plain, it being used in this case both as a soil term and a geological term, to describe the process by which the material was accumulated. In materials of this kind geology and soil science meet, and the same term may be used to designate material that is at once an embryonic or at least infantile soil and a geological formation.

FIG. 8—Bluff on *parana* below Maues, Lower Amazon, showing slaglike iron masses incipiently developed. (Photograph by C. F. Marbut.)

Katzer's description does not refer, however, to soils of this kind. He is attempting to describe the upland soils of the region that have been developed from water-laid material or, as he and many German authors call it, alluvial material and therefore alluvial soils.

While the upland soils of the Inner Amazon Basin have been derived from material accumulated by sedimentation, the soils are about as far removed in their character from alluvial soils as is possible. They are in no sense characterized by the infantile simplicity of profile features such as are present in alluvial soils. On the other hand, they differ in none of their fundamental characteristics from soils derived from residual material of the same general character as the sedimentary, providing the soils from the two kinds of materials have been developed under identical conditions and have reached the same stage in their development. Excepting the relatively unimportant recent alluvial "soils," the soils of the Inner Amazon Basin are found

to be normal well-developed upland soils, predominantly mature and containing no higher percentage of immature or imperfectly developed soils than is found in any other region of its kind in the world, so far as our existing knowledge will permit us to draw a conclusion.

General Features of Amazon Soils

In a region like the Amazon valley where climatic, botanic, and topographic as well as geologic conditions vary very little throughout its whole extent it is inevitable that the soil variations will be relatively small also. In such a region soil variations would be small even if geological conditions were not uniform, since all the *active* factors of the soil environment are nearly uniform. In a region like the Inner Amazon Basin consisting predominantly of mature upland the prevailing soil must have lain in place long enough to have been influenced by the active factors of the environment. Experience gained in the study of soils over a wide area in the United States has shown that soil development and topographic development have a rather intimate relationship. A mature topography in any region is covered by soils of rather definite characteristics, which are often described as those marking a mature stage of soil development.

Profile

A mature soil is one that has assumed the profile features characteristic of the predominant soils on the smooth uplands within the general climatic and botanic region in which it is found. Theoretically it is a soil that has adjusted itself to its physical environment, and its characteristic profile features are a product of that environment. In the humid timber-covered regions of the world the same features are common to all the upland soils in which the soil mass is not subject to continual shifting but on the other hand has lain in place through an important part of an erosion cycle.

The predominant upland soils of the Inner Amazon Basin are normal well-developed, mature soils of this class. They comprise a true soil layer, or *solum*, which differs in color, texture, chemical composition, number, and arrangement of parts from the geological formation beneath it. Its thickness will average somewhat less than eight feet. This horizon, or layer, is itself not uniform in character throughout its whole thickness. It consists of layers, or horizons, there being two that are specially well marked. These consist of a relatively light-textured surface layer (A horizon) and a relatively heavy-textured layer (B horizon) beneath it, usually extending from about 12 to 15 inches beneath the surface to about 40 inches beneath. Beneath the solum lies a third layer that may be lighter or heavier than the second but is usually heavier than the first. This is the

parent geological material of the region. In color the surface horizon is brown or pale yellow; the second, or heavier, layer is yellowish, reddish yellow, yellowish red, or red; while the third is variegated gray and red.

A collection of 33 samples from the relatively light-textured surface horizons at the same number of widely distributed localities, when subjected to mechanical analysis, showed an average of 29 per cent of clay and 50 per cent of combined silt and clay. Samples from the relatively heavy-textured layer from 30 localities widely distributed over the region contained an average of 43 per cent of clay and 63 per cent of combined silt and clay.

Chemical analyses of 15 samples of the relatively light-textured surface horizon, or layer, showed an average of 13.52 per cent of alumina, 3.26 per cent of iron oxide, and 71.93 per cent of silica. The average percentage of each of these constituents in the heavier horizons of the same number of soils is 19.34, 6.00, and 64.42, respectively.

Not only do the averages of the samples show a higher percentage of fine material in the second horizon, but the mechanical composition of each sample, when analyses of both horizons from the same soil section were made, showed the same relationship. That this relationship of the surface horizon to the underlying horizon is identical with that found in soils developed from what is known as residual material is shown by the following data from two soils from the Piedmont Plateau region of North Carolina, for which no one has suggested any other source than the disintegration of the crystalline rocks. These are true residual (*grundschutt*) soils as Katzer defines them. In this soil the relatively light-textured surface layer has 14 per cent of clay and 44 per cent of combined silt and clay while the relatively heavy layer has 39 per cent of clay and 60 per cent of combined silt and clay. In chemical composition the light-textured surface layer has 83.19 per cent of silica, 2.58 per cent of iron oxide, and 6.91 per cent of alumina while the heavy-textured layer beneath it has 57.58 per cent of silica, 9.51 per cent of iron oxide, and 21.53 per cent of alumina.

It will be seen that the processes of soil development have produced the same result in the soils of the Amazon region derived from unconsolidated sands, silts, and clays as in the soils of the Piedmont Plateau of Georgia where the soils have been derived from disintegrated crystalline rock material.

Texture

One of the most important characteristics of soils is their texture, or the relative and absolute sizes of the mineral particles of which they consist as well as the relative amounts of the various sizes present.

TABLE I—MECHANICAL COMPOSITION OF AMAZON VALLEY SURFACE SOILS*

(*Percentages*)

MAP INDEX NUMBER	SAMPLE NUMBER	DEPTH (INCHES)	COARSE AND MEDIUM SAND	FINE SAND	VERY FINE SAND	SILT AND CLAY	CLAY
1	30804	0–8	10.0	6.0	3.0	80.0	33.0
2	30823	0–12	15.0	34.0	10.0	39.0	23.0
3	30838	0–16	13.0	14.0	14.0	58.0	35.0
4	30842	0–10	21.0	38.0	9.0	29.0	20.0
5	30851	0–8	14.0	7.0	17.0	60.0	42.0
6	30855	0	0.7	5.0	9.0	84.0	49.0
7	30873	0–6	26.0	15.0	10.0	46.0	16.0
8	30875	0–8	7.0	23.0	10.0	60.0	23.0
9	30881	3–12	1.6	7.0	17.0	73.0	23.0
10	30931	0–10	0.2	11.0	47.0	41.0	21.0
11	30936	0–12	0.6	3.0	36.0	60.0	20.0
12	30940	0–16	14.0	8.0	19.0	57.0	21.0
13	30951	0–18	33.0	28.0	10.0	25.0	18.0
14	30957–a	0–7	31.0	29.0	12.0	25.0	13.0
15	30958	0–8	0.0	16.0	11.0	74.0	45.0
16	30970	0–8	0.0	3.0	27.0	70.0	49.0
17	30994	0–24	39.0	25.0	5.0	26.0	23.0
18	30999	0–7	35.0	26.3	4.0	32.0	24.0
19	31009	0–14	0.3	36.0	22.0	41.0	27.0
20	31018	0–16	2.0	21.0	31.0	46.0	18.0
21	31027	0–10	0.3	13.0	16.0	70.0	33.0
22	31040	0–10	3.8	44.0	15.0	37.0	28.0
23	31049	0–24	1.2	47.0	33.0	18.0	3.0
24	31061	0–12	1.0	19.0	40.0	40.0	11.0
25	31072	0–8	2.5	11.0	34.	51.0	20.0
26	31081	0–12	3.2	35.0	20.0	41.0	38.0
27	31088	0–15	0.4	29.0	30.0	40.0	14.0
28	31095	0–14	14.0	34.0	11.0	40.0	36.0
29	31102	0–12	0.0	0.6	0.6	99.0	70.0
30	31106	0–12	0.7	7.0	34.0	58.0	40.0
31	31115	0–12	2.2	18.0	19.0	59.0	44.0
32	31120	0–12	8.0	9.0	5.0	77.0	52.0
33	31929–30	0–8	25.0	27.0	9.0	38.0	6.0
34	31574	0–3	1.5	23.5	17.5	58.0	31.0

*The localities from which samples in Tables I, III, V, VIII, were taken are shown by the index number on the map, Fig. 9. All mechanical analyses were made in the laboratories of the Bureau of Soils by Messrs. A. A. White and J. B. Spencer.

TABLE II—MECHANICAL COMPOSITION OF SOILS IN THE COASTAL PLAIN OF THE UNITED STATES

(*Percentages*)

SAMPLE NUMBER	DEPTH (INCHES)	COARSE AND MEDIUM SAND	FINE SAND	VERY FINE SAND	SILT AND CLAY	CLAY
(a) 29415–16	0–5	42.6	29.5	1.8	23.0	6.0
(b) 29422–23	0–16	47.8	24.6	2.0	23.5	4.5
(c) 29676–77–78	0–18	11.0	51.5	13.0	26.1	8.1
(d) 32300–01	0–10	15.8	46.2	15.5	22.9	8.9
(e) 32339–40	0–10	28.0	24.5	4.3	38.2	7.8
(f) 32345–46	0–20	34.0	45.0	9.5	9.1	4.3
Average		29.9	36.7	7.7	23.8	6.6

(a) and (b) Accomac County, Virginia; (c) Prince George's County, Maryland; (d) Carnegie, Georgia; (e) Ocilla, Georgia; (f) Hazelhurst, Georgia.

TABLE III—MECHANICAL COMPOSITION OF AMAZON VALLEY SUBSOILS

(*Percentages*)

MAP INDEX NUMBER	SAMPLE NUMBER	DEPTH (INCHES)	COARSE AND MEDIUM SAND	FINE SAND	VERY FINE SAND	SILT AND CLAY	CLAY
35	30824	36–60	14.0	33.0	10.0	43.0	27.0
36	30829	14–60	20.0	19.0	20.0	40.0	30.0
37	30830	at 18	0.2	3.0	20.0	77.0	48.0
38	30836	12–55	13.0	14.0	5.0	69.0	58.0
39	30839	18–54	7.0	5.0	2.0	85.0	60.0
40	30843	11–18	7.0	19.0	9.0	66.0	63.0
41	30876	12–36	4.0	12.0	6.0	77.0	41.0
42	30882	12–24	0.7	3.0	12.0	84.0	37.0
43	30937	12–60	0.4	2.0	26.0	83.0	39.0
44	30939	18–54	0.0	7.0	33.0	60.0	33.0
45	30941	15–45	13.0	15.0	7.0	64.0	27.0
46	30957	8–60	31.0	31.0	10.0	23.0	18.0
47	30972	45–60	0.0	1.0	13.0	86.0	62.0
48	30983	12–36	0.4	14.0	37.0	48.0	34.0
49	30984	60–84	0.4	8.0	41.0	51.0	41.0
50	30995	48–120	26.0	19.0	5.0	46.0	29.0
51	31001	14–60	19.0	26.0	7.0	47.0	37.0
52	31011	36–60	0.3	25.0	26.0	47.0	36.0
53	31020	36–60	1.0	10.0	18.0	71.0	44.0
54	31029	36–60	0.0	4.0	10.0	87.0	61.0
55	31041–42	10–60	2.3	30.0	14.0	53.0	40.0
56	31050	60–108	0.7	31.0	21.0	46.0	32.0
57	31062	10–40	0.5	12.0	32.0	56.0	32.0
58	31083	36–70	2.3	30.0	16.0	52.0	44.0
59	31090	30–60	0.0	1.5	17.0	82.0	46.0
60	31104	40–90	0.0	0.0	00.4	99.0	83.0
61	31107	12–48	0.5	4.0	26.0	69.0	60.0
62	31116	12–30	1.8	12.0	23.0	63.0	49.0
63	31121	12–48	7.0	6.0	4.0	82.0	56.0
64	31933	26–60	18.0	17.0	7.0	58.0	33.0
65	31575	14–60	9.5	18.3	13.0	69.0	44.0

TABLE IV—MECHANICAL COMPOSITION OF SUBSOILS IN THE COASTAL PLAIN OF THE UNITED STATES*

(*Percentages*)

SAMPLE NUMBER	DEPTH (INCHES)	COARSE AND MEDIUM SAND	FINE SAND	VERY FINE SAND	SILT AND CLAY	CLAY
(a) 29417–18	6–40	41.0	30.0	1.9	25.0	8.0
(b) 29424–25	12–40	65.3	14.5	1.0	15.5	7.5
(c) 29679–81	18–50	30.0	48.9	2.8	18.0	14.0
(d) 32302–04	11–60	9.3	19.0	10.0	57.0	45.0
(e) 32341–44	11–70	11.5	14.0	8.0	69.0	45.0
(f) 32348–51	41–144	19.0	36.0	12.0	38.0	30.0
Average		29.3	27.1	5.9	37.1	24.9

*See locations of the corresponding surface soils in footnote to Table II.

This has been considered of sufficient importance to be taken as one of the commonest bases of soil definition.

The Inner Amazon Basin is one of two large areas in the world whose soils have developed from unconsolidated deposits of sands and clays of great thickness under the influence of high humidity and relatively high temperature. The other region is the Atlantic and Gulf coastal belts of the United States. The most illuminating and instructive description that can be made of Amazon region soils is to compare them with those of the Coastal Plain of the United States.

It is to be expected that the Amazon soils, having developed from sand, silt, and clay deposits, would be more or less sandy. They differ greatly in this respect, however, from those of the Coastal Plain of the United States.

In the Coastal Plain the surface soil over large areas is a sand or loamy sand; that is, it either consists wholly of sand grains and is therefore incoherent or it contains a small percentage of fine-grained material. Of 170 soils selected at random from as many localities in the upper Coastal Plain in the Carolinas, Georgia, and Alabama 60 per cent consisted of sand in the upper 8 to 12 inches, and a considerable percentage of the rest contained barely enough fine-grained material to place them in the sandy loam group. Among an equal number of specimens of soil collected from the upland of the Amazon valley, the surface horizon to a depth of 6 to 14 inches is in only one case lighter than a sandy loam. In most cases it is heavier.

The differences between the soils of the two regions are still more striking when the soils are compared as to their relative content of clay, silt, and very fine sand. In 42 soils from the Amazon region, selected from all parts of it, the average clay content of the surface soil is 30 per cent, the combined silt and clay content 52 per cent, and the very fine sand content 20 per cent. Thirteen of these soils, or about 30 per cent of them, contain 35 per cent of clay or more; and the maximum clay content is 70 per cent. The highest percentage of very fine sand is 47 per cent, and 11 soils contain 30 per cent or more.

In 40 soils selected at random from the upper Coastal Plain of the United States the average percentage of clay in the surface soil is 8, and only 15 per cent of the soils contain more than 10 per cent of clay. The average percentage of combined silt and clay is 25, and only 13 per cent contain as much as 40 per cent of both constituents. The average percentage of coarse and medium sand combined is, however, 17; the maximum is 45 per cent, and none of the soils contains less than 1 per cent.

The average percentage of fine material (very fine sand, silt, and clay) in 42 Amazon soils is 72, while the content of the same constituents in 42 Coastal Plain soils is only 40 per cent. The maximum percentage of these constituents in the Amazon soils is 98; while 27

of them, or more than 75 per cent, contain more than 60 per cent. The highest percentage of these constituents in the Coastal Plain soils is 76, and only 13 per cent contain more than 60 per cent. It will be readily seen from the foregoing comparison that the Amazon soils are distinctly heavier than the nearest comparable soils in the United States.

The differences are equally striking when the subsoils are compared. In the Amazon valley the average percentage of fine material (very fine sand, silt, and clay) in the subsoils of the same soils used in the comparison made above is 84; the maximum percentage is 99, and 31 of them, or more than 75 per cent, contain more than 70 per cent of these constituents. In the Coastal Plain the average percentage of these constituents in 40 subsoils is 58; the maximum is 76, and only 9 per cent contain as much as 70 per cent. The percentage of clay alone in the Amazon soils is large when compared with that in the Coastal Plain soils—the average percentage in the Amazon region being 44, the maximum being 83, and more than 60 per cent of the samples containing a higher percentage of clay than 40. In the Coastal Plain the average percentage is 25, the average maximum is 43, and less than 2 per cent contain as much as 40 per cent of clay. Details are shown in Tables I-IV.

Color

Color in soils is significant mainly as indicating either the percentage and character of organic matter present or the degree of soil and subsoil aeration and drainage. Uniformly colored brown, yellow, or red subsoils are characteristic of development in situations that are well drained and free throughout the true soil profile from the presence of ground water. The whole thickness of the soil profile has lain above the level of the permanent water table. Gray colors or mixed colors indicate complete or partial water logging of the soil or subsoil during the period of development. With certain exceptions, which need not be discussed here, the relative content of organic matter in soils, usually in the upper part of the surface horizon, is indicated by the relative darkness of the soil color.

The prevailing brown, yellow, and red subsoils of the Inner Amazon Basin and the absence of evidences of incomplete oxidation in both the A and B horizons are still further evidences of the general good surface drainage of the Amazon region and of the normal character and course of development of its soils.

The general features of the color profile are essentially uniform throughout the area. The soils vary widely in the thickness of the several color horizons, but in the mature or well developed soils all the color zones are present and occur in the same order from the sur-

TABLE V—CHEMICAL COMPOSITION OF AMAZON VALLEY SOILS*

(*Percentages*)

MAP INDEX NUMBER	SAMPLE NUMBER	DEPTH (INCHES)	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	K_2O	Na_2O	P_2O_5	N
4	30842	0–10	82.72	2.43	7.29	trace	.22	.16	.16	.18	.12
66	30868	0–6	80.10	1.86	9.60	.20	.16	.30	.19	.06	.10
67	30827	0–6	82.55	2.58	8.28	.14	.08	.10	.16	.13	.09
68	30989	0–14	74.63	3.98	11.64	.20	.22	.38	.21	.06	.13
26	31081	0–12	77.53	3.47	10.98	.04	.10	.29	.38	.05	.10
27	31088	0–15	87.40	2.02	5.54	.28	.28	.36	.25	.06	.07
24	31061	0–12	89.62	2.04	4.26	.19	.02	.31	.18	.03	.06
21	31027	0–10	77.35	3.38	11.10	.03	.16	.90	.24	.03	.13
69	30958	0–8	61.54	5.86	19.07	.18	.18	.84	.25	.15	.18
70	31713–14	0–16	40.80	7.82	31.50	.30	.14	.04	.20	.11	.22
71	31735–36	3–10	34.40	8.00	31.00	.01	.01	.16	.06	.13	.40
32	31120	0–12	53.55	7.66	25.20	.08	trace	.02	0.14	.15	.09
	Average		70.18	4.26	14.61	.14	.13	.32	.20	.09	.14

*All chemical analyses were made in the laboratories of the Bureau of Soils by Messrs. G. J. Hough, R. S. Holmes, and G. Edgington. All analyses were made by the fusian method, and the percentages show the proportion of the total quantities of each constituent present.

TABLE VI—CHEMICAL COMPOSITION OF SOILS IN THE COASTAL PLAIN OF THE UNITED STATES

(*Percentages*)

SAMPLE NUMBER	DEPTH (INCHES)	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	K_2O	Na_2O	P_2O_5	N
(a) 29127	0–18	92.23	1.18	2.55	.37	.13	.04	.36	.03	.04
(b) 30225–26	0–12	91.00	1.75	3.20	.50	.11	.20	.26	.07	.03
(c) 30231–32	0–12	93.00	1.28	2.55	.31	.11	.16	.14	.03	.04
(d) 32313–14	0–6	71.60	8.60	8.20	.26	.18	.59	.42	.25	.13
(e) 32333–34	0–10	91.50	.53	4.25	trace	trace	.09	.16	.02	.02
(f) 32612–13	0–8	87.05	1.40	3.93	trace	.18	.34	1.71	.11	.05
(g) 29407–08	0–20	89.60	1.14	4.55	.18	.14	1.62	.11	.03	.04
(h) 29677–78	0–18	87.25	3.60	4.20	.25	.34	1.50	.40	.10	.03
Average		87.90	2.43	4.18	.23	.15	.57	.44	.08	.05

(a) Thomasville, Georgia; (b) Raiford, Georgia; (c) Meigs, Georgia; (d) Eufala, Alabama; (e) Dothan, Alabama; (f) Wilson County, North Carolina; (g) Dorchester, Maryland; (h) Prince George's County, Maryland.

TABLE VII—CHEMICAL COMPOSITION OF SOILS IN CERTAIN LOCALITIES OF THE UNITED STATES OUTSIDE THE COASTAL PLAIN

(*Percentages*)

SAMPLE NUMBER	DEPTH (INCHES)	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	K_2O	Na_2O	P_2O_5	N
(a) 28507	2–12	79.06	3.57	9.13	.47	.46	1.91	.50	.17	.08
(b) ?	0–12	78.16	2.88	9.53	.61	.49	1.67	1.04	.09	.15
(c) 29846	0–12	73.35	2.86	11.51	1.16	.78	2.82	1.31	.14	.14
(d) 4457–a	0–12	74.53	3.27	11.00	1.70	1.41	2.57	1.14	.05	.09
Average		76.27	3.14	10.29	.98	.78	2.24	1.00	.12	.11

(a) Wayne County, Ohio; (b) Columbia, Missouri; (c) Belleville, Kansas; (d) Paducah, Texas.

TABLE VIII—CHEMICAL COMPOSITION OF AMAZON SUBSOILS

(*Percentages*)

MAP INDEX NUMBER	SAMPLE NUMBER	DEPTH (INCHES)	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	K_2O	Na_2O	P_2O_5	N
40	30843	11–48	59.47	6.17	22.51	trace	.24	.18	.18	.22	.06
72	30869–70	6–60	73.50	2.90	14.50	.20	.15	.49	.16	.05	.06
73	30828–29	6–60	78.20	3.50	12.11	.15	.07	.09	.13	.11	.04
74	30990–91	14–60	73.86	4.15	13.20	.22	.20	.36	.15	.05	.04
75	31082–83	12–73	71.00	4.80	15.15	.05	.11	.48	.42	.04	.06
59	31090	30–60	59.34	11.33	19.40	.24	.41	1.37	.38	.04	.03
57	31062–64	14–80	76.70	5.10	12.10	.08	trace	.82	.27	.03	.05
76	31028–29	10–60	64.00	6.50	19.50	.04	.33	1.42	.48	.08	.08
49	30984	60–84	73.46	4.16	14.23	.12	.12	.57	.52	.01	.04
77	31925	32–60	81.26	2.04	9.87	.10	.25	.64	.13	.03	.04
78	30959	8–60	61.25	7.12	20.52	.10	.10	.80	.26	.11	.06
79	31715–16	16–62	41.30	6.75	36.00	.30	trace	.14	.10	.10	.08
80	31738–39	16–48	37.88	9.40	35.10	trace	trace	.17	trace	.09	.06
63	31121	12–48	51.19	9.27	26.36	.04	.09	.16	.27	.25	.04
	Average		64.46	5.95	19.18	.12	.15	.55	.25	.09	.05

TABLE IX—CHEMICAL COMPOSITION OF SUBSOILS IN THE COASTAL PLAIN OF THE UNITED STATES*

(*Percentages*)

SAMPLE NUMBER	DEPTH (INCHES)	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	K_2O	Na_2O	P_2O_5	N
(a) 29129	18–48	82.98	2.91	9.20	.30	.16	.03	.04	.03	.03
(b) 30227–29	12–70	81.00	3.20	10.30	.36	.10	.21	.33	.06	.02
(c) 30233–35	12–39	77.60	4.50	11.90	.35	.16	.18	.28	.06	.03
(d) 32315–16	7–48	69.00	12.76	11.57	.26	.22	.54	.42	.33	.01
(e) 32335–37	11–49	83.75	1.15	9.60	trace	trace	.11	.18	.01	.01
(f) 32614	8–32	71.78	5.35	13.73	trace	.26	.35	1.67	.08	.02
(g) 29409	20–32	80.74	2.25	10.58	.74	.26	1.97	.44	.08	.02
(h) 29679	18–40	77.71	9.44	5.20	.30	1.09	2.91	.30	.12	.02
Average		78.07	5.19	10.26	.29	.28	.79	.46	.10	.02

*For localities from which samples were taken see footnote to Table VI.

TABLE X—CHEMICAL COMPOSITION OF SUBSOILS IN CERTAIN LOCALITIES OF THE UNITED STATES OUTSIDE THE COASTAL PLAIN*

(*Percentages*)

SAMPLE NUMBER	DEPTH (INCHES)	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	K_2O	Na_2O	P_2O_5	N
(a) 28508–9	12–36	72.66	5.74	12.35	.35	.82	2.35	.66	.13	.05
(b) 29347–48	12–40	68.15	4.33	14.03	1.19	1.21	2.83	1.12	.15	.08
(c) ?	12–36	71.19	4.55	14.71	.95	1.17	2.08	1.20	.09	.04
(d) 4457–b–c	12–40	58.83	2.85	8.86	12.21	1.76	2.23	1.19	.10	.03
Average		67.70	4.37	12.49	3.67	1.24	2.37	1.04	.12	.05

*For localities from which samples were taken see footnote to Table VII.

face downward. The upper or surface horizon is yellowish brown and is mixed with enough organic matter to give it a dark color. As a rule it ranges in thickness from a few inches to somewhat less than a foot; a thickness of more than 6 inches is unusual. The second horizon is yellow. It varies much more widely in thickness than the dark-colored horizon, ranging from a few inches to a maximum of about 10 feet. In general it varies with the texture of the soils, being thicker in sandy and thinner in heavy soils. In the light-textured soils, such as those prevailing on the north side of the Amazon below Manãos and in general in the river mouth region, it is thick and includes not only the lower part of the upper (or A) horizon but all of the relatively heavy-textured (or B) horizon. In a few cases this horizon was found to be yellow in heavy soils. This was notably the case at São Salvador on the Amazon a short distance below the mouth of the Madeira.

The third horizon is red, brownish red, or yellowish red and ranges in thickness from about a foot to 6 or 8 feet. It is usually thickest in heavy soils, especially those that have rather heavy or well-oxidized subsoils, and thinnest in the sandy soils. It is therefore thickest in soils with the thinnest yellow horizon and vice versa. In the heavier soils it usually consists of the relatively heavy B horizon, but in the lighter soils it includes only the lower part of the B horizon.

The fourth horizon is predominantly gray with spots and streaks of red or yellow. The spots and streaks may consist either of soft red clay or of iron oxide highly concentrated, even constituting in some cases an impure iron ore. The relative proportions of red and gray differ, but in most cases the gray predominates sufficiently to impart to the horizon a definite gray appearance where exposed in the river bluff. This is especially true below the upper foot of the top of the horizon and thence downward for several feet.

The iron oxide is concentrated in vertical and horizontal streaks and spots and seems to have a maximum concentration just beneath the red horizon, decreasing downward. In the river bluffs of the lower Amazon, seemingly confined to the region with sandy soil, this zone on outcrop passes through the induration, possibly concentration also, of the iron oxide streaks and spots into a hard mass. It is resistant to direct erosion but is undermined by the river and breaks off in blocks, which accumulate at the foot of the bluff. Exposure to rain wash removes the clay between the meshes of the iron oxide mass and leaves the latter as a porous slag-like block of impure iron ore (Fig. 8). Such masses were not seen above Mamia or Coary on the Solimões nor at any point on the Beni, Abunã, or Purús systems. The zone of gray clay with red streaks and spots running through it in all directions was present in these areas, however, but it was not found indurated. It was not unusual to find sandy layers

cemented with iron oxide on several horizons beneath the soil, even below water level in the river. All the so-called *cachoeiras* on the Madeira below where the crystalline rocks dip beneath the river level, from the vicinity of Porto Velho up to Guajará-mirim and on the Purús and Acre Rivers, consisted of nothing more than a local accumulation in the river channels of slabs of this sandstone too large to be removed by the current.

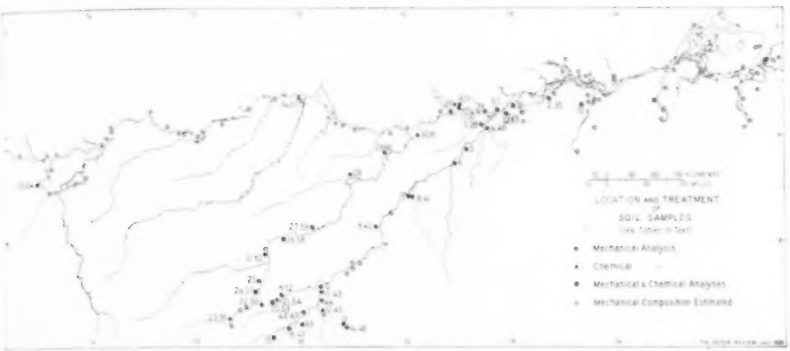

FIG. 9—Index map for location and treatment of the soil samples listed in Tables I, III, V, VIII. Numbers on the map correspond to index numbers in the tables. See also Fig. 7.

CHEMICAL COMPOSITION

Heavy rainfall and a high average temperature, if permitted to act on a given layer of material long enough, produce a soil in which the original silicate minerals are well broken down and from which the constituents made soluble by such breaking down have been removed. The predominant constituents remaining in the soil are those which under the particular prevailing conditions are relatively insoluble. This is a characteristic feature of such soils while in a virgin condition, and their low content of soluble constituents has no relation whatever to the work of man.

In most cases such soils have developed under a cover of arboreal vegetation and are, for that reason, characterized by a low or relatively low content of organic matter. The soils of the Amazon region have a low percentage of organic matter and a low content of alkalis, alkaline earths, and generally of silica.

In 12 samples of surface soils from widely distributed localities in the Amazon valley the average percentage of silica is 70.18, of ferric iron oxide 4.26, of alumina 14.61, of calcium oxide .14, of potash .32, and of organic matter about 3.00.[5]

In 14 subsoils from widely separated localities—not, however, in all cases the subsoils underlying the surface soils just summarized—

[5] The percentage of organic matter is approximate only.

there is an average of 64.46 per cent of silica, 5.95 per cent of ferric iron oxide, 19.12 per cent of alumina, .12 per cent of lime, .55 per cent of potash, and about 1 per cent of organic matter. In no case did any soil or subsoil contain any lime carbonate or any other carbonate. The unweathered and unleached parent rock in the southwestern part of the region contains free lime carbonate. A sample taken at Rio Branco on the Acre River at a depth of 30 feet from the surface

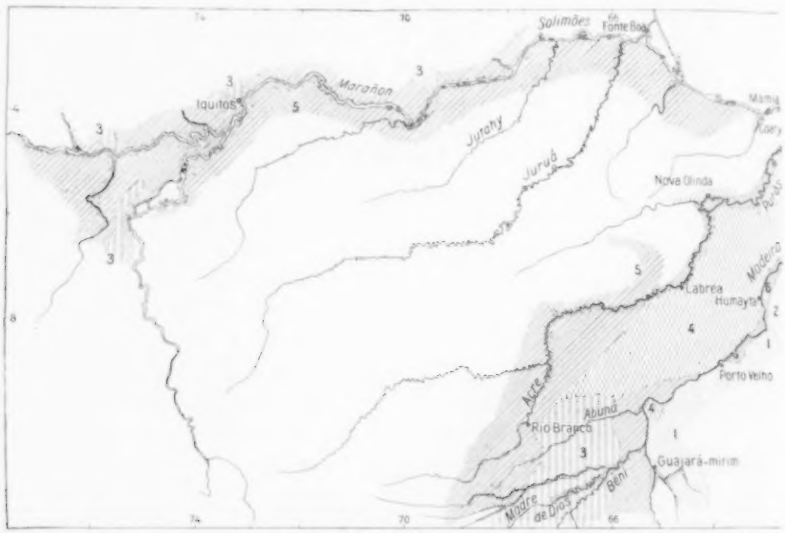

FIG. 10—Soil map of the Inner Amazon Basin. Five groups of upland soils and the alluvial soils are distinguished.

contained 3.5 per cent of lime and 0.62 per cent of CO_2 from carbonates. A sample taken at the same place and at a depth of 15 feet contained no carbonate. It is apparent, though not absolutely demonstrated by these facts, that leaching of the carbonates even in this material, which is rather heavy, has extended to a depth of more than 15 feet.

What seemed to be the same geological material as that containing the lime carbonate at Rio Branco was seen at many places along the Acre River and at a few places on the Purús. Tables V and VIII show the chemical composition of soil samples from the Amazon, and Tables VI and IX samples from the southeastern parts of the United States.

STRUCTURE AND CONSISTENCY

Structure is a term used to designate the size and shape of the soil aggregates made by the natural grouping of the soil particles. It is that characteristic which gives "mellowness" to the soil. The grouping of the soil particles has some relation to the kind and amount of alkalis and alkaline earths present in the soil either in the mineral

or the organic matter. Where the soil has been completely leached of these constituents except such as may be locked up in resistant minerals present in the soil, such as feldspars, the soil particles are not grouped into aggregates and the soil has a *single-grain* structure.

In the Amazon valley, except in the case of the soils consisting essentially of sand, there are practically no soils with single-grain structure. They are predominantly granular, the granules being

For mapping of alluvial areas on a larger scale (1:5,000,000) see the authors' map, "Flood Plain Belts of the Inner Amazon Basin," *Geogr. Rev.*, Vol. 15, 1925, Pl. V, facing p. 642.

rather large, about the size of peas. Such structure is usually designated as coarse granular or nut structure. There seem to be no soils with the remarkably fine granular structure of the soils on our Great Plains. The granulation in the Amazon region is much better than in the Coastal Plain of the United States, partly because of the sandy character of the soils in the latter region.

The Amazon soils are remarkably friable. Tough plastic soils are not entirely absent but are so unusual that the region becomes conspicuous in this respect. The studies of tropical soils in Central and South America by H. H. Bennett and the authors of this paper point strongly to the conclusion that one of the most striking if not *the* most striking characteristic of tropical soils is their ready friability, even where the texture is extremely heavy.

Drainage and Oxidation

The Amazon valley is a great plain but not a flat plain. It is thoroughly dissected by a series of branching valleys that reach all

parts of it. In details the surface relief varies, and it is not entirely free from areas with imperfect drainage. Outside the relatively narrow alluvial plains of the rivers and creeks that traverse all parts of it swamps are of very rare occurrence. No upland swamp was seen or heard of by the Rubber Commission. On the basis of the investigation of the authors the assertion seems to be justified that not more than ten per cent of the area of upland in the Inner Amazon Basin is imperfectly drained and probably not one per cent is permanently covered with water.

The soils of the Inner Amazon Basin are predominantly well drained to depths of four feet or more, are well oxidized to this depth, and show that throughout the period of their development they have not been subjected to the influence of excessive moisture in the form of a high water table—not at any rate for a period long enough for the disappearance of all such evidence. This statement is based on the assumption that characteristics long since recognized as indicators outside the tropics can be used in the tropics also.

The Main Soil Groups

The upland soils of the region have been grouped into five units, or groups, on the basis of the texture of the surface and the color and physical characteristics of the subsoils. A sixth group is constituted by the alluvial soils. The groups are:

1. Sandy loams with yellow friable subsoils usually consisting of sandy clay.
2. Fine sandy loams with predominant yellow to reddish yellow friable clay to sandy clay subsoils.
3. Clay loams and clays with red or reddish friable clay subsoils.
4. Clays and clay loams with heavy imperfectly oxidized clay subsoils usually at a depth of two feet or less.
5. Very fine sandy loams with reddish or reddish yellow friable clay subsoils.
6. Alluvial soils.

The accompanying soil map (Fig. 10) shows the areas in which each of these groups of soils predominates. It is manifest that this is a very general map and makes no pretense to accuracy. An inspection of the map (Fig. 9) showing the location of samples will show the number of places from which data were obtained and on which the map is based.

The soils of the yellow sandy loam group are similar to the Norfolk sandy loam in the Coastal Plain in the southeastern states of the United States (see tables). They differ from the Norfolk sandy loam in having a zone of iron accumulation, usually at a depth of about five to

six feet in areas where no erosion has taken place. In eroded areas the iron zone has been exposed at the surface, where it is usually broken into small irregular fragments and strewn about. This seems to be identical with the material called "laterite" in India and Africa. The iron oxide of this zone indurates where exposed at the surface, and in such cases it presents itself as a layer of slag-like iron ore. It rarely extends back beneath the overlying soils more than a few feet. Beyond that it becomes merely a zone in which soft reddish iron oxide has been segregated in cracks and along joint planes.

The fine sandy loam group consists of soils very much like those of the previously described group, differing mainly in the finer grain of the sands present. They usually overlie a zone of iron oxide segregation, but being finer in grain they are somewhat more drought-resistant.

The third group consists predominantly of deep friable clay loams, silty clay loams, and clays with friable but heavy reddish to yellowish red clay subsoils. The structure is coarse granular, and the content of organic matter is rather high for forested soils. The layer of organic matter is usually somewhat thicker than three or four inches, and there is complete absence of zones of induration or compaction. The layer containing organic matter is thicker than in most timbered soils. There seems to be no zone of iron oxide accumulation beneath the soil, though small round iron concretions are often present in the subsoils or, where erosion has taken place, in the soil.

The chemical analyses of this soil show high percentages of alumina, moderately high of iron oxide, but low of alkalis and alkaline earths. The potash content in the sample from the southwest of Boim is much lower than that in the samples from Acre territory and eastern Bolivia. Notwithstanding the low potash and lime content the natural forest growth is heavy, showing that the soil is productive. It withstands the long dry seasons well. There is no zone of iron oxide segregation beneath this soil.

About the fourth group, consisting of clay with rather shallow heavy and somewhat intractable subsoils, little was learned. It was seen at Humayta, at Labrea, and at a few other places on the Purús. The treeless belt (*campos*) extending from Humayta southwestward to and around the head of the Pixuna River seems to lie on soils of this kind, and rumors were heard of stretches of treeless country in other parts of the belt between the Madeira and the Purús. In general it must be admitted that the data for showing so large an area of this group are very few. Such soils are found in pronounced development on the Purús above Ipiranga and below Nova Olinda, and the soil at Labrea seemed to be of this character. It is not a region of wet lands, however, though its soil seems to be somewhat less deeply weathered than are the other soils of the region

The fifth group includes soils that in general are much like those of the third group. They have a thick layer of darkish-colored surface soil with a somewhat higher percentage of organic matter than is usually present in timbered soils. The texture of the surface soil is predominantly a very fine sandy loam, so far as our knowledge goes. The subsoil is a friable reddish to red clay, well oxidized to a depth of five or six feet.

There can be no doubt that this group of soils covers a large area in the Acre territory and eastern Bolivia; and, as shown on the map, it stretches along the upper Amazon. The character of the soils in the interior is unknown. It is probable that the watershed plateaus in the region drained by the Purús, Juruá, and Jutahy are covered with soils similar to those of this group or the third group. The importance of this region as a producer of wild rubber of good quality indicates the presence of large areas of soils on which *Hevea brasiliensis* does well. The studies by the authors in other parts of the region show that the tree does better on the soils of the third and fifth groups than on those of any other. For this reason it seems highly probable that the Juruá-Jutahy region is largely covered by soils of these two groups. They are fundamentally alike and are about equally productive. The occurrence at several places in the upper Amazon Basin of small areas of soils belonging in the third group suggests the occurrence of larger areas in the interior. A high, smooth plateau extends far to the southward, according to local information, from the vicinity of Fonte Boa; and the soils are reported to be productive and the region covered with heavy forests. The soils of the third and fifth groups produce the greater number of rubber trees (*Hevea brasiliensis*) and of Brazil-nut trees.

The alluvial soils constitute a sixth group. There are in general two kinds. (1) Well drained loams and very fine sandy loams occupy the immediate banks of the rivers in a narrow belt ranging from a few feet to a few hundred yards in width. They lie on the natural levee and are moderately well drained, subject to flooding for a short period each year, but highly productive. (2) Heavy, imperfectly drained to poorly drained "back swamp" soils are often dark in color and heavy throughout the whole section. They are subject to long periods of inundation. Considerable areas are treeless. The belts in which they lie contain many shallow lakes and swamps.

Determinants of Productivity

The productivity of a soil is determined only in part by its chemical composition. The texture, structure, water-holding capacity, and other physical features are of equal importance. Another matter to be borne in mind in this connection is the fact, now widely recog-

nized in practical farming, that the chemical characteristics of a soil can be easily and cheaply modified to the extent of causing an important increase in production. On the other hand, the fundamental physical features of the soil are very resistant to change or even to modification. The fundamental characteristics of soil, such as its texture, have never been changed by man except to a slight degree. A light-colored soil, even where cultivated continuously for hundreds of years, remains light-colored, and a sand remains a sand. Some dark-colored soils have changed under cultivation to lighter color, but the black soils of the great sub-humid areas of the world have not shown any perceptible lightening in color under cultivation.

It has been shown in the preceding pages that the soils of the Amazon valley are moderately heavy in texture at the surface and quite heavy in the subsoil. They are distinctly heavier than the soils of the Coastal Plain in the United States, the region approaching the Amazon region nearest of all in the United States in rainfall, topography, and source of soil material and not differing from it greatly in temperature from the soil point of view inasmuch as both regions are essentially free from soil frost throughout the year. Notwithstanding the heavy texture, these soils have an unusually friable structure.

The Amazon soils are predominantly well drained, well oxidized, and deeply weathered. They have a low content of organic matter as a whole but a rather high content for soils developing under forest cover. Under intensive cultivation the organic content, if we may base an opinion on experience gained in the cultivation of light-colored soils in other parts of the world, will without much doubt disappear rather rapidly. The topography on which these soils lie is largely favorable to agriculture. The proportion unfit for cultivation because of steepness of slope is relatively small, and by far the greater part of it is capable of utilization for grazing. A very small part of the uplands of the region is rendered unavailable to agriculture because of swamps.

Chemically these soils have very low contents of lime carbonate and potash and moderately low contents of phosphoric acid and are poor in this respect when measured by the standards prevailing in Europe and America. The low percentages of alkalis and alkaline earths suggest that under cultivation their highly favorable structure would disappear rather rapidly. From the point of view of soil physics they are productive soils. Their chemical composition indicates that, if we may base an opinion regarding this matter on the agricultural history of regions in which soils similar to these in chemical composition have been cultivated, they will require fertilization in a short time after intensive cultivation has been begun. The region in mind is the Coastal Plain region of the United States, including both the highly sandy soils and those less sandy.

General Conclusion

Timberlands have been conquered by man always at relatively slow rates, and especially is this true of such regions in the tropics. Light-colored soils developed under the leaching effect of a high rainfall, and especially of water that has become warm by the time it begins its percolation through the soil, have never been able, without the application of manures in some form, to produce good or profitable yields for more than a few years after they have been brought under cultivation.

The Amazon region cannot produce the things which the world consumes in largest quantities and which require large areas of land for their cultivation, such as wheat and high-grade live-stock products. And those products which it can produce in large quantity will inevitably meet with vigorous competition such that the rate of production increase will be inevitably slow.

Finally, even if these conditions were other than they are, it seems probable that, except through an economic revolution of a character wholly unknown and unforeseen, the development of this region has been delayed beyond the critical period in the history of the world. It would seem as if world conditions were not likely again to favor such rapid developments as took place in the United States, Russia, and Argentina in the end of the nineteenth century. Their development was only partly due to their soil and climatic conditions, highly favorable though they were; the other factor consisted in the rapid rate at which European and American industrial development was taking place and the tremendously rapid increase of a population that did not produce its own food. Existing conditions or those likely to exist for a considerable time in the future do not indicate the probability of any such rapid relative increase in the food-consuming but not food-producing population of the world as took place during the latter half of the nineteenth century.

The pioneers of the world have been members of the white race. The world's colonization development has been performed largely by them. Other races have entered and occupied regions after the white man has developed them; but pioneering, the opening up of new countries, has been a white man's specialty. The white man has not yet found it possible to be an original producer of high efficiency in tropical climates. The last few years have shown that with precautions he can live out his natural life span in the tropics, but he has not yet shown any possibility of engaging in the work of production in any other capacity than as an organizer and overseer.

ACTUAL TEMPERATURES OF SOUTH AMERICA*

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WHAT are the actual temperatures one would experience if one spent a month at a time in the upper Amazon country? The diagram (Fig. 2) sets it out to the eye. It is indeed hot there, but more notable than the degree of heat is the monotony of it. Day after day the temperature runs up almost to the same point: 93°, 93°, 88°, and 90° for the first four days of January, and 69°, 70°, 69°, 73° are the bottom points, the coolest moments of the same days: so on through the month—the hottest month of the year. Those are points on the thick line. The coolest month is June. The thin lines which represent the temperature in June show afternoons at 97°, 97°, 95°, and 95°, with nights at 70°, 71°, 67°, and 67°. Not much cooler when you come to look at it; or, if the nights were cooler, the days certainly were not!

But what are the marks of a hot month, or a cold one? The mean of all the temperatures in January is only a little higher than the mean for June, the figures being 81° and 77° respectively. Moreover, high afternoon temperatures are indicated oftener in June than in January. The real point, however, is that the range of tem-

FIG. 1—Location map for the places discussed in the text. The black dots represent the stations for which temperature graphs are given in the succeeding figures. Scale approximately 1:80,000,000.

* A first series appeared in the *Geographical Review*, Vol. 6, 1918, pp. 240–267, "The Real Temperatures Throughout North and South America." This introduced the diagrammatic method here followed, of lines connecting daily maxima and minima for the hottest month of the year and the coldest month on the same diagram. The writer obtained good additional data on the American Geographical Society's Expedition to the Argentine, Brazil, and Chile in 1918.

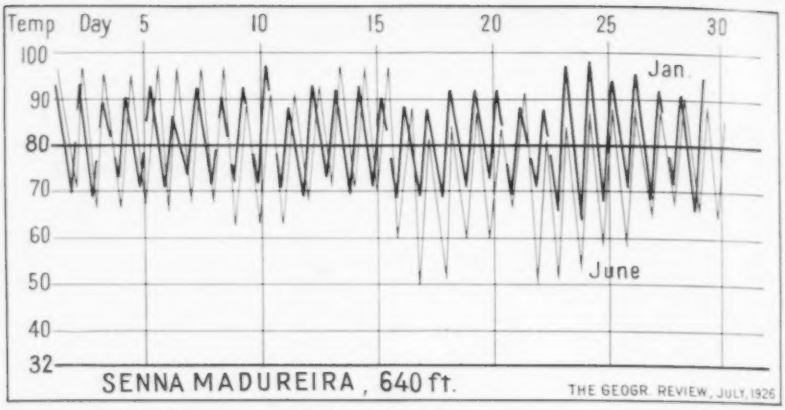


FIG. 2—Year 1916

January: mean 81°; range 22°; variability 1.3°
June: mean 77°; range 27°; variability 4.8°

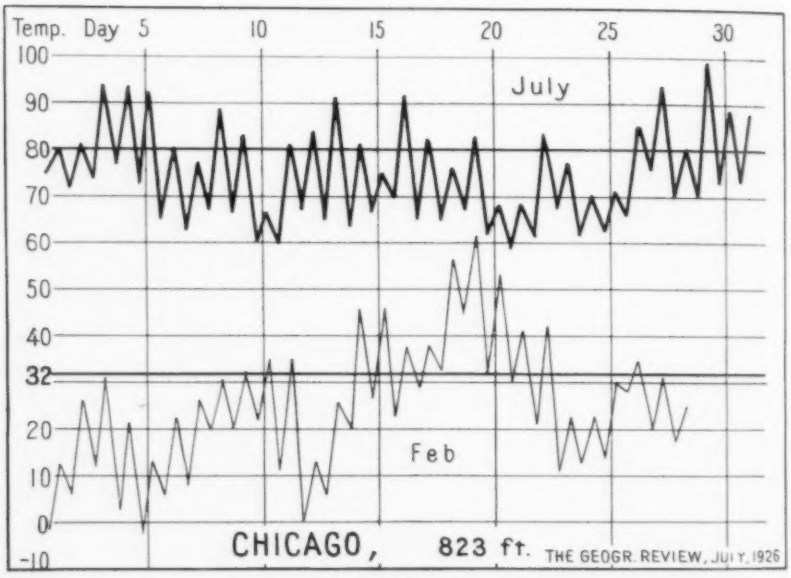


FIG. 3—Year 1913

July: mean 74.5°; range 15.1°; variability 5°; rainfall 3.3 ins.
February: mean 24.5°; range 15.5°; variability 9.3°; rainfall 2.0 ins.

perature, the difference between maxima and minima, is greater in the cooler month. June has more clear sky; more sunshine falls on the ground to warm it by day; and more radiation through the cloudless air cools it by night. These tropical ranges, the differences from day to night, are very great. In the United States they are far smaller. We have winter. Chicago, for instance (Fig. 3), has a winter fifty degrees cooler than summer. That gives our winter a definite and distinct character. Of such a winter the Amazon knows nothing. What we

have called *hottest* and *coldest* months at Senna Madureira are but four degrees different. We should not notice the difference from month to month, but we should notice the 27-degree change from day to night. It is truly said that the night is the winter of the tropics. And would not nights of a temperature in the fifties, as in the latter part of June (see Fig. 2), be distinctly noticed by persons who live day after day with the thermometer in the eighties and nineties? I fancy that is why Dr. Hoffman found a high mortality by bronchial and pulmonary

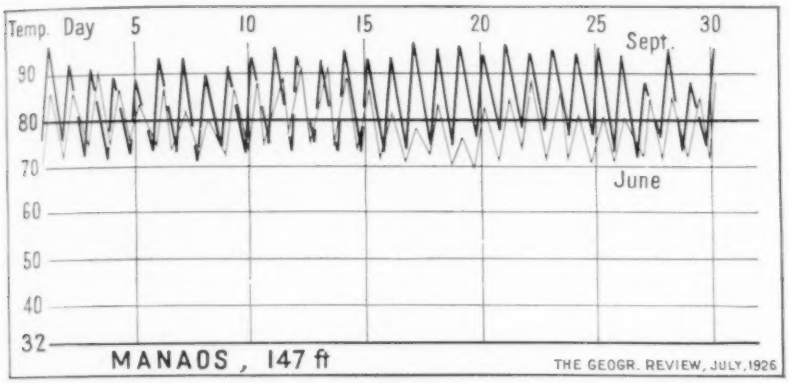


FIG. 4—Year 1916

September: mean 84°; range 19°; variability 1.8°; rainfall 0.5 in.; relative humidity 73
June: mean 79°; range 12°; variability 2.2°; rainfall 5.2 ins.; relative humidity 82

affections in the valley of the Amazon among those who slept at night without proper covering.

Senna Madureira is a good example. It is on a tributary of the upper Purús River near the Bolivian border, several hundred miles east of the Andes and 900 from Manáos. It may be called hot, since the thermometer rose to 90° twenty times in January and fifteen times in June. It rose above 80° every day. That is not a remarkable temperature; the highest temperature, 97°, is often surpassed in the northern United States. But it was a fearfully persistent temperature. All the maxima were contained in the narrow range between 88° and 97°. At night it always cooled off to a point between 64° and 74°.

IN THE HEART OF THE AMAZON

Manáos is fairly in the heart of the Amazon country.[1] Here is the same type of temperature as at Senna Madureira. The maxima

[1] All the Brazilian data are due to the courtesy of Dr. Henrique Morize, formerly Head of the Division of Meteorology and Astronomy in the Brazilian Ministry, who had them compiled for me in 1918 from the records of the latest year completed in the office files, 1916. There is no reason to suppose 1916 an unusual year. The Annuario do Observatorio Nacional de Rio de Janeiro for 1918 gives the monthly mean temperatures at Manáos for the six years ending with 1916. September and June in this series range between 82° and 85° for September and for June between 80° and 83°, where our values for 1916 were 84.1° and 79.2°. Figures for Rio and elsewhere point to 1916 as a normal year.

are always over 80°, and in September twenty-two of them were over 90°. They are even more uniform than on the Purús. June, with five inches of rain, is the coolest month, as at Senna Madureira; but the closely interwoven lines show the essential similarity in warmth of the months.

In each case the selection of hottest and coldest month has been made from the record of the one year that we have used. The mean values for several years at Manáos do not make September the hottest

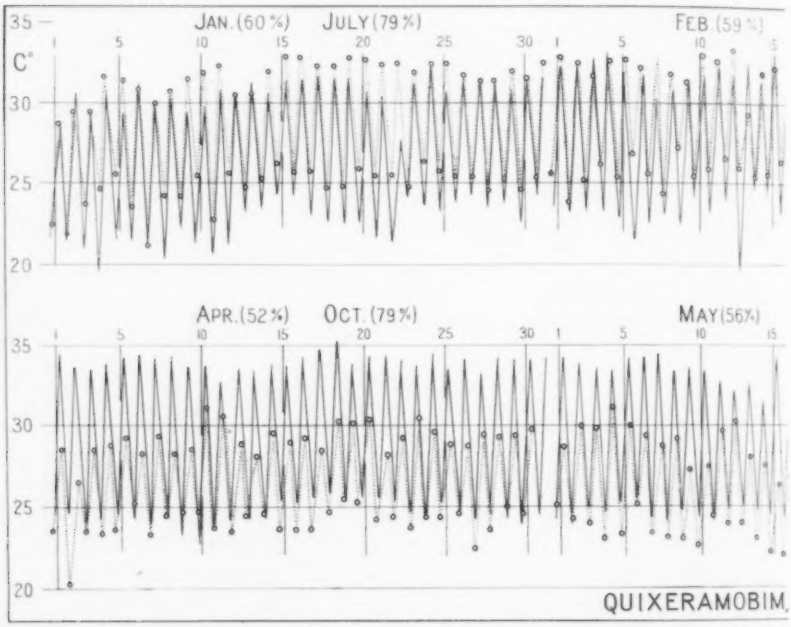


FIG. 5—Year 1910. The solid line shows maxima and minima from January to June. Circles connected by dotted line mark values for the rest of the year.

month nor June the coolest; but so near the equator there is not enough difference in the mean monthly temperatures for this selection to be very significant, as is shown by the figures for Manáos:

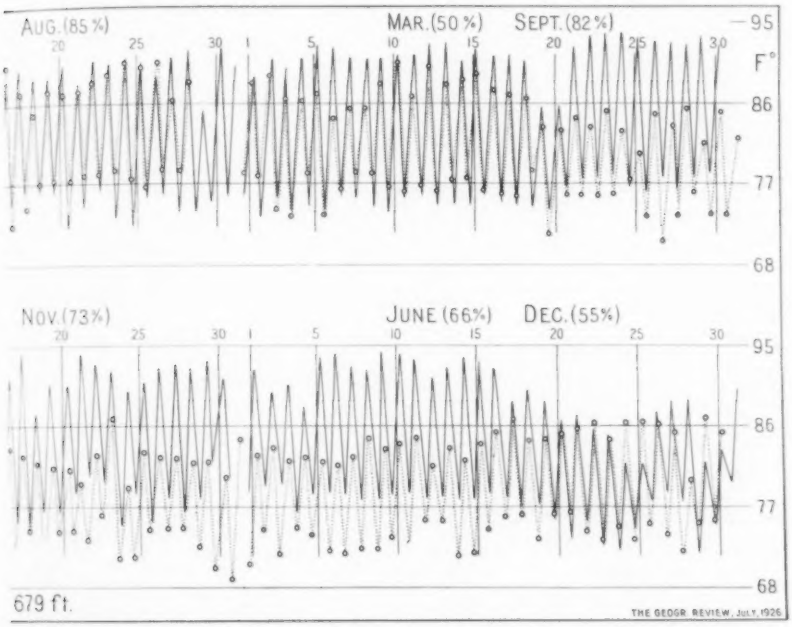
	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
°F.	81	80.7	80.7	80.7	80.7	81	81.3	82.3	82.8	83	82.8	81.3

The real seasons are the seasons of rain and drought, and it is to these that the names *verão* and *inverno* locally refer. The only considerable differences of temperature that occur are associated with the diurnal range, as has been stated, a clear sky giving a larger range than a cloudy one and a cloudy sky often being associated with the season of rains. This appears to be the case mostly in the Amazon

country, but it is not always so. At many points in the Argentine there is more clear sky in the rainy season than in the dry season.

The Yearly Record at Quixeramobim

To check up on this and the character of the hottest month as regards days of exceptionally high temperature let us glance at a



Percentage of the possible hours that the sun shone is indicated in parenthesis after the names of the months.

record for a whole year at some place near the equator. I have data at hand for Quixeramobim, Ceará, 1910. This station is on the plateau of eastern Brazil about a hundred miles from the Atlantic. The hottest temperature of the year was 95.3°, reached on October 18. The same month had the highest mean temperature, 87.1°. The coldest day was August 13, with 66.9°; but May had a lower monthly mean—only three degrees lower, however.

Figure 5 enables us to compare the six possible diagrams, each of two months half a year apart: January-July, February-August, etc. There are obvious differences. The October-April diagram, for instance, is unlike that for December-June, having the respective diurnal ranges of 16.7° and 9.3°, and of 14.6° and 10.4°. The diagram that includes the hottest and coldest months, October-May, covers the whole series of temperatures of the place very well, even if it does

not include such types of variability as in December. Numerically, however, these are of much the same order as those of October-May, October variability being 0.8°, that of May 1.6°, and that of December 2.2°. The station associates much sunshine, large diurnal range of temperature, and little rain on the one hand with much cloudiness, small diurnal range of temperature, and much rain on the other. Our choice of hottest and coldest months has given us months that are fairly typical of the year.

TABLE I—TEMPERATURE, SUNSHINE, AND RAINFALL AT QUIXERAMOBIM, 1910

MONTH	TEMPERATURE				SUNSHINE	RAINFALL (*Inches*)
	MEAN	RANGE	MAX.	MIN.		
January	82.6	12.2	91	69.5	60	4.9
February	83.3	11.3	91.8	73	59	3.1
March	81	10.1	90.5	70.7	50	11.9
April	79.9	9.3	88	68.2	52	7.1
May	78.4	9.5	88.1	68.9	56	10.9
June	78.8	10.4	86.9	70.5	66	0.6
July	79.8	15.3	90.7	67.3	79	0
August	81.7	15.8	92.8	66.9	85	0
September	83.3	16.7	93.7	73.4	82	0
October	87.1	16.7	95.3	73	79	0
November	84.4	15.4	94.2	74.8	73	0.9
December	84.5	14.6	94.4	71.8	55	4.6

IN THE TOCANTÍNS BASIN

Near the western border of the plateau that bounds the Amazon Basin on the east we have a record from a station, Conceiçao, on the west branch of the Tocantíns, the Araguaya. Though Senna Madureira is 1300 miles away, the curves indicate the same march of temperature as on the Amazon. However, the diurnal range is greater on the plateau, and greater extremes of temperature are reached. Four times in October the maximum reached 100°. It passed 90° almost every day in the month. In June it failed of 90° a single day, while the nights commonly dropped to 60°.

On the Tocantíns, a hundred miles to the southeast, is a station which shows a range greater still, though both the months available are from the dry season. The elevation of Porto Nacional is 250 feet greater than that of Conceiçao. This in itself tends to increase the range. We are getting farther into the plateau of east Brazil and farther away from the inner basin of the Amazon. The heat of September is very great, passing 90° every day and touching 100° ten times

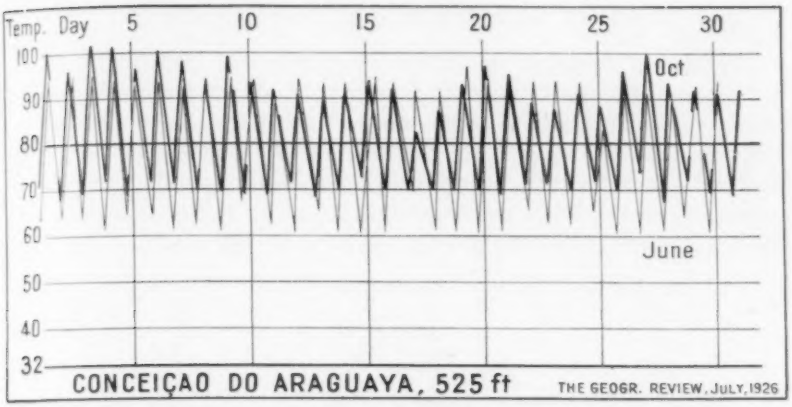


FIG. 6—Year 1916

October: mean 82°; range 24°; variability 2.1°
June: mean 78°; range 30°; variability 1.2°

in the month. The nights, on the other hand, are always below 70° and often near 60°. In July only half of the maxima run above 90°, and almost all of the minima are below 60°—ten of them as low as 55°. The variability is low. There is still tropic monotony of heat. These places along the great rivers are necessarily deep below the surface of the plateau, but it is down there that the people live. The climate below reflects many conditions on the upland. Winds descending from the upland may easily augment the heat. The "winter" mean is here eight degrees cooler than "summer," but the night is thirty-three degrees cooler than the day!

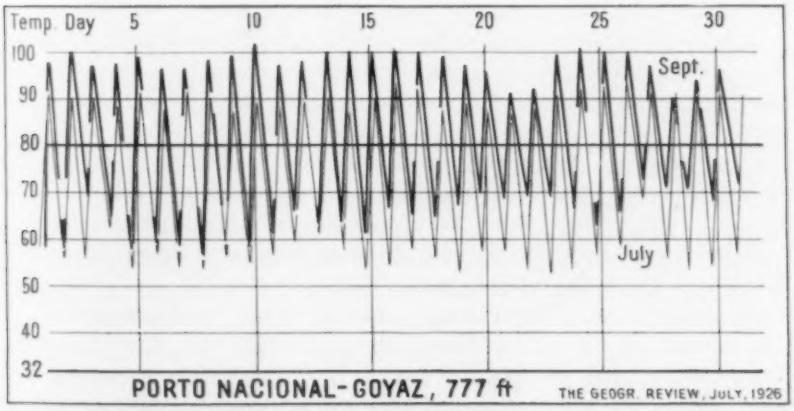


FIG. 7—Year 1916

September: mean 81°; range 33°; variability 1.9°
July: mean 73°; range 33°; variability 1.5°

We may compare the two months October and May for Quixeramobim (Fig. 5), where the annual and daily ranges are much diminished by the nearness to the ocean. Maritime character we shall find displayed in Figure 8 for the island of Fernando Noronha, 200 miles off the coast, and Figure 9 for the seaport Recife, commonly known by its English name Pernambuco. The highest temperature reached at Fernando Noronha was 85°, the lowest 75.5°. The whole

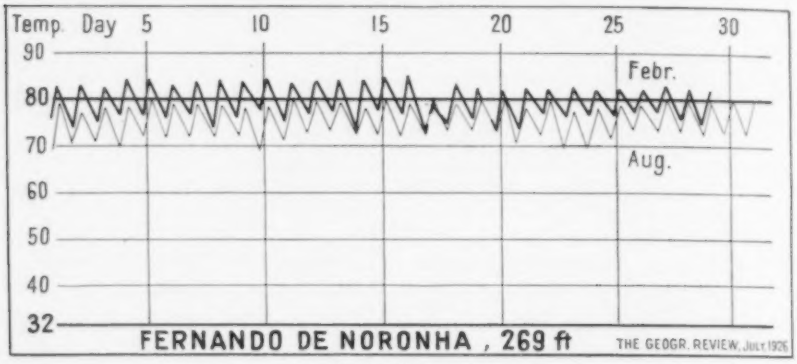


FIG. 8—Year 1916

February: mean 79°; range 7°; variability 0.9°; rainfall 4.0 ins.; relative humidity 87
August: mean 76°; range 6°; variability 0.9°; rainfall 0.3 in.; relative humidity 81

year's fluctuations of the thermometer were contained between 70° and 85°. The absolute maximum in six years was 85.8, the absolute minimum 65.5. Contemplation of this diagram must make an impression of extreme monotony. The warm month reminds one of Bermuda, but Bermuda has winter.

The coast temperatures run very much like those offshore. While the variability is the same as on Fernando Noronha, the effect of the continent is shown in the increase of range. Both March and July were rainy months, September to January inclusive usually run dry but not rainless. If the greater diurnal range for the rainier month catches the eye, it is of interest that the five inches of March rain fell on 11 rainy days while the two inches for July were spread out over 17 days. In six years the absolute maximum temperature at Recife was 88.5°, the minimum 66.2°.

It is well known that the discomfort of great heat increases with the humidity of the air. Of course the air in the basin of the Amazon is very moist. On the plateau the air is drier and the heat less uncomfortable. Relative humidities for the warmer month and cooler month respectively are: Manáos, 73, 82 per cent; Quixeramobim, 53, 75; Fernando Noronha, 87, 81; Recife, 73, 74.

Spells of Weather in Matto Grosso

In the corner of western interior Brazil draining to the Paraguay we find the tropical monotony broken by most pronounced spells of weather. This is in the southern part of the province of Matto Grosso. There are records from Cuyabá, at the head of navigation by the Paraguay and Corumbá, the western terminus of the railway from São Paulo. The watershed of the Paraná basin is the plateau 2000 to 3000 feet in elevation extending across Brazil from the At-

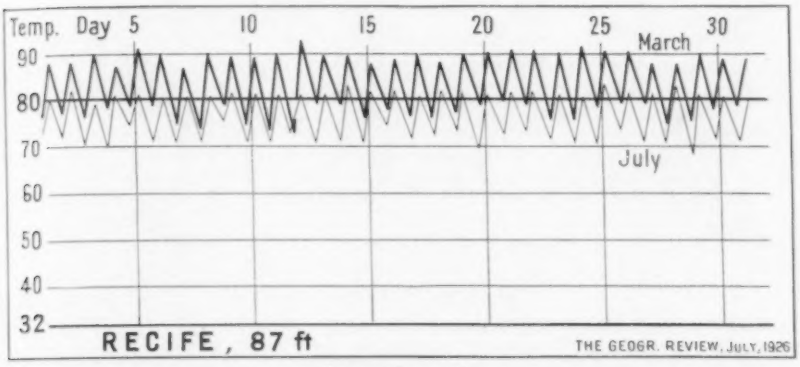


Fig. 9—Year 1916

March: mean 83°; range 13°; variability 0.9°; rainfall 5.0 ins.; relative humidity 73
July: mean 77°; range 9°; variability 0.8°; rainfall 2.0 ins.; relative humidity 74

lantic to the junction of the river Guaporé with the Madeira. On the south it is open to the winds from the Argentine pampa with the successive passing of high and low barometer areas from west to east.

As we see from Figures 10 and 11, Cuyabá gets a touch of these winds in June, and Corumbá feels them strongly. The region shows a temperature régime unknown in the rest of Brazil. Winter is separate from summer, and here are distinct spells of weather.

In spite of irregularities the summer is still tropical, running in the high nineties at Cuyabá and getting close to 100° at Corumbá, which is lower though 200 miles farther south. The spells of weather are so pronounced at Corumbá as to bring frost at times.[2] An astonishing result at Corumbá is the large variability, the largest I have yet found anywhere. It should be noted, however, that these are cold spells only; there are no equivalent hot spells. What corresponds on these diagrams to warm spells is merely tropical cool month weather overlapping the warm season oscillations on the cool side. It seems to be precisely parallel to the hot spells that characterize the tempera-

[2] Julius Hann: Handbuch der Klimatologie (3rd edit., 3 vols., Stuttgart, 1908–1911), Vol. 2, p. 406.

tures at San Francisco.[3] On first working out this variability of 13.3 for Corumbá, a station in the torrid zone, I could hardly credit the result. I wrote to Dr. Morize. It happens that the observer at Corumbá, whose reliability is beyond all question, does not report fractions of a degree on his thermometer. Thus he reports the absolute maxima and minima for the first four months of 1916 at Corumbá in degrees centigrade as 40.0, 19.0, 39.0, 19.0, 39.0, 14.0, 39.0, 23.0. His neighbor at Cuyabá reports for his station 34.0, 23.1, 32.7, 20.5,

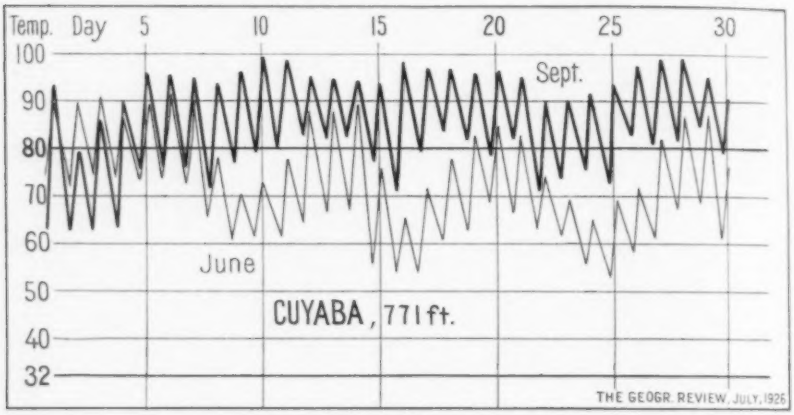


FIG. 10—Year 1916

September: mean 84°; range 17°; variability 3.6°; rainfall 4.0 ins.
June: mean 72°; range 16°; variability 6.3°; rainfall 0.0 in.

32.7, 20.5, 33.3, 21.6, which is better. It is not wise to neglect fractions, especially of degrees centigrade, although it does not matter for the purposes of this study. The observer wrote a letter describing the country about Corumbá and assuring me that the great fluctuations in the thermometer are actual. A still better confirmation is found in the correspondence of the observations at Cuyabá, to the north and at Corrientes, 600 miles away, in the Argentine Republic. While there are great differences between the course of the temperature at all these stations, their accordance is such as to demonstrate their essential accuracy.

It is significant that the cold spells at Corrientes come a day or two before they are felt at Corumbá and that the wind at Corrientes is blowing from the south at least a day before the drop in temperature at Corumbá. Thus on the 6th, 7th, and 8th of June the wind at Corrientes was steadily south and southeast, changing to northerly at noon on the 9th. The drop at Corumbá came on the 8th, 9th, and

[3] *Geogr. Rev.*, Vol. 6, 1918, pp. 261 and 262. When that article was written those spells were not fully understood. I now believe those bursts of several days' extreme heat injected into the mild temperatures usual at San Francisco result from a northeasterly wind, which brings heated air from the Great Valley to the coast.

10th. The second cold spell at Corumbá was severe from the 15th to the 18th. Corrientes had southerly winds all through the 14th and 15th, with change to northerly and northeasterly on the 16th. Again the drop in temperature in Matto Grosso, June 22 to 25, was preceded in Corrientes by southerly winds which began on June 19 and continued to the 26th; then east winds on the 27th were followed by south winds to the end of the month, preceding the final cold spell at Corumbá. I have at hand no record of the wind at the Brazilian stations, but the Argentine record leaves no doubt that we see here cool

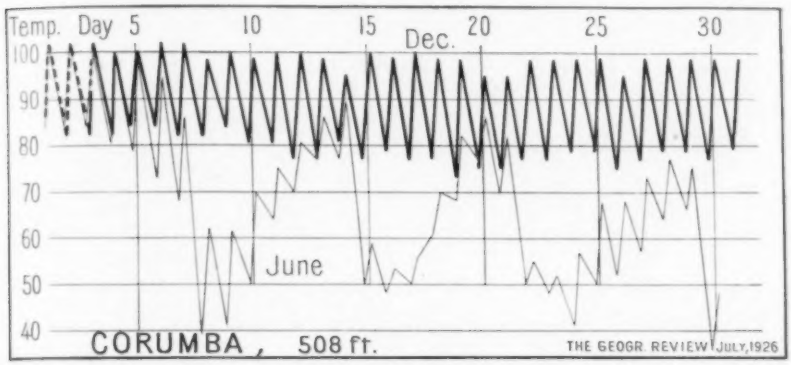


FIG. 11—Year 1916

September: mean 89°; range 20°; variability 1.7°
June: mean 69°; range 13°; variability 13.3°

Argentine air on its way to Brazilian thermometers. The northbound air that left Corrientes on June 8 and 9 had a temperature in the early morning of 39°, on the 15th of 41°, on the 23rd of 27°, and on the 28th of 44°. At each occasion the sky at Corrientes was overcast and the barometer high. One millimeter of rain fell at Corrientes on the 4th, one on the 13th, twenty-five on the 14th, and traces on the 23rd.

It is curious—and characteristic—that the cold spell at Corrientes is much less noticeable than at Corumbá, where it interrupts even tropical warmth as sharply as a norther in Texas. Here are the maxima and minima for Corumbá and Corrientes, June 4 to 9 side by side:

1916, June	4	5	6	7	8	9
Corumbá	100	98	95	86	62	61
	80	79	73	68	39	41
Corrientes	61	57	53	56	57	63
	40	43	44	39	39	42

At Corumbá the temperature fell 61° from 100 on the 4th to 39° on the 8th; but at Corrientes, where the cold wave, so to speak, originated, the drop was only 21°, from 61 to 39.

All this has interest for the Republic of Paraguay, for which I have no data. Lying between Matto Grosso and the Argentine, Paraguay is in the path of these winter cold waves, which must advantageously interrupt the tropical régime of its temperatures.

The Serra do Mar

The mass of the people of Brazil inhabit the eastern plateau. The breaking down of this plateau to the sea in the so-called Serra

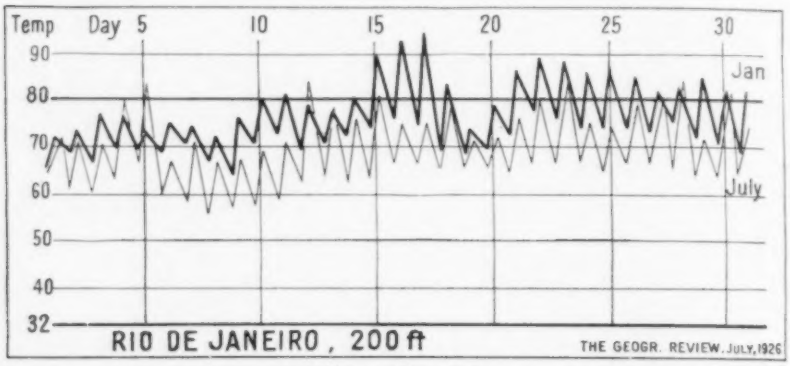


Fig. 12—Year 1916

January: mean 76°; range 12°; variability 3.7;° rainfall 4.7 ins.; relative humidity 80
July: mean 70°; range 12°; variability 3.2°; rainfall 1.6 ins.; relative humidity 78

do Mar, a one-sided mountain range like the Cévennes in France, affords abrupt changes of level that cause local contrasts of climate. We have some striking records for the plateau border in Mt. Itatiaya above Rio de Janeiro, São Paulo on the plateau above Santos, and Curityba above Florianopolis. Itatiaya is 100 miles west of Rio and 9000 feet higher, the weather station being some 2000 feet below the summit. Both this station and Rio are near the tropic, but there is very little separation of summer from winter. The temperatures have the steady tropical march without spells of weather. The greater diurnal range at Itatiaya in September is probably accompanied by clear skies. Rio is notoriously cloudy. The relative humidity on the mountain is 55 in September, 72 in June. Down at Rio the values are 80 and 78.

Such irregularities as the hot spell of January 15–17 at Rio result from delay or interruption of the sea breeze. Twenty-five days out of thirty in summer this breeze sets in about one o'clock and continues until seven. In winter it starts an hour later, ends an hour sooner, and blows with less force. As the land trends east and west at Rio, the sea breeze comes from the south-southeast and at once substitutes cooler sea air for air heated over the land by a tropical sun. As this

cuts off the afternoon rise in temperature the maximum temperature of summer comes at noon. Here are temperatures and wind directions through a typical and an exceptional day in 1910:

	Midnight	6 a. m.	11 a. m.	12 m.	1 p. m.	3 p. m.	4 p. m.	7 p. m.	10 p. m.	Mean
Typical Day	79	77	84	86.4	85.5	85.4	85.4	84	84	81.5
January 28			WNW	N	SSE	SSE	SSE	ESE	N	
Exceptional Day	86	83	90	92	92	93.2	86	85	81.3	85.6
January 24	W	WSW	W	W	NW	NNW	SSE	SSE	WNW	

On the exceptional day the breeze did not begin till 4 p. m., and the temperature went much higher than usual. Four such days ended

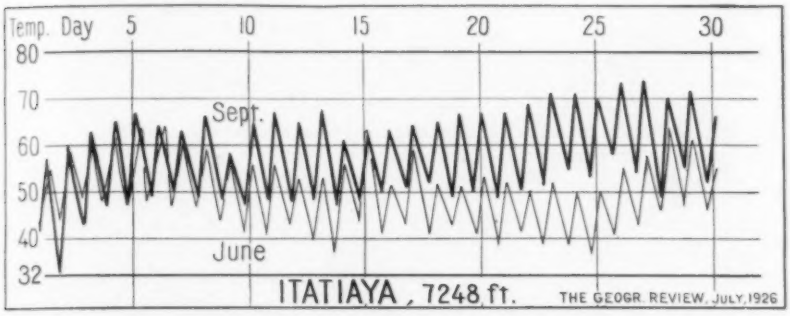


FIG. 13—Year 1916

September: mean 57°; range 17°; variability 2.9°
June: mean 49°; range 12°; variability 3.3°

on January 24 and had the highest temperatures of the month—82.7, 84.2, 85.6, and 85.8. The hot spell of January 15, 1916, is probably the result of a similar delay in the sea breeze. This happened again on the 21st and the days following. As the winter (July) sea breeze begins later and blows with less force, it does not prevent the maximum temperature from taking its normal place in the afternoon. The warmest hour is 2 p. m., and 3 p. m. and 4 p. m. are warmer than 1 p. m. A delay of the sea breeze at this season does not bring about much change in the temperature.

Santos has a special interest as being the sea approach of the great population that lives on the healthful plateau, the temperature of which is represented by São Paulo. Santos has not had a good reputation for health. It is nearly landlocked behind an island and gets less sea breeze than Rio. In agreement with this is the large diurnal range, half again as large as Rio: its hot-month afternoons are several degrees warmer, though it is a hundred miles farther from the equator. São Paulo is six degrees cooler for its 2500 feet elevation and is much of the same type in its weather, though drier and having a slightly larger diurnal range. The appearance of a smaller range between summer and winter may be due to the use of June as the winter month.

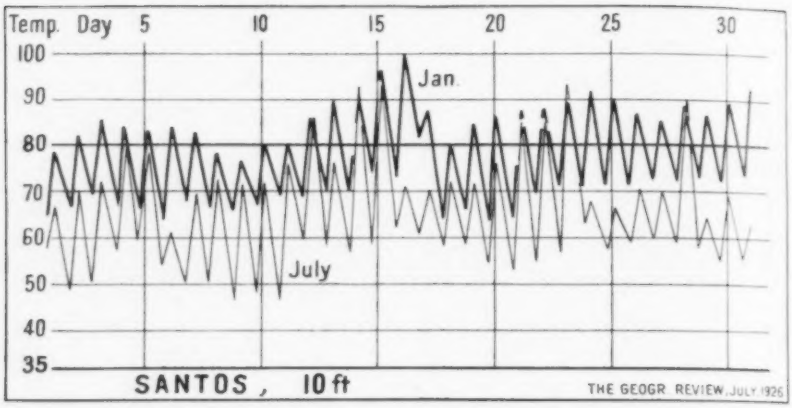


FIG. 14—Year 1916

January: mean 78°; range 17°; variability 3.5°; rainfall 0.9 in.; relative humidity 84
July: mean 66°; range 17°; variability 4.5°; rainfall 4.5 ins.; relative humidity 88

São Paulo has an admirable climate of less summer heat than Chicago. It is mild in winter but tropical in its steadiness.

Florianopolis is on the landward side of an island and lies about ten miles from the ocean. The small daily range here must be caused by cloudy skies. It produces an effect of greater difference between summer and winter than at Curityba nearly 3000 feet above and a hundred miles northwest. But summer is 17 degrees warmer than winter at both places. The annual range shown at Curityba is 67° (90°–23°), at Florianopolis 41° (88°–47°). Both places have a hot summer, but the cool winter of Florianopolis becomes cold at Curityba. Some of the winter days at Curityba have the extraordinary range of 43 degrees. July had seven nights of frost. There is some

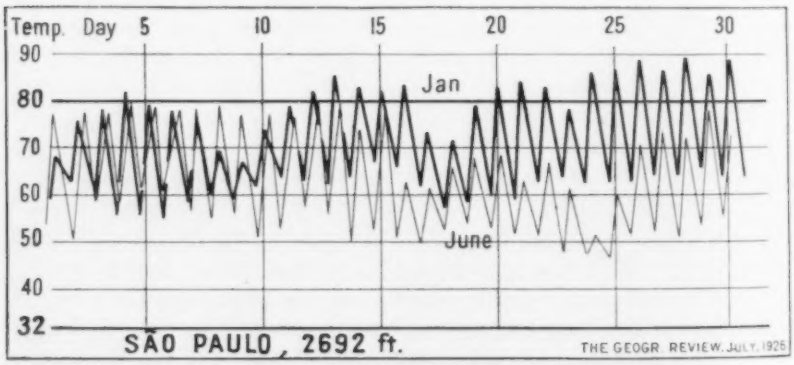


FIG. 15—Year 1916

January: mean 71°; range 18.5°; variability 3.5°
June: mean 63°; range 18.7°; variability 4.3°

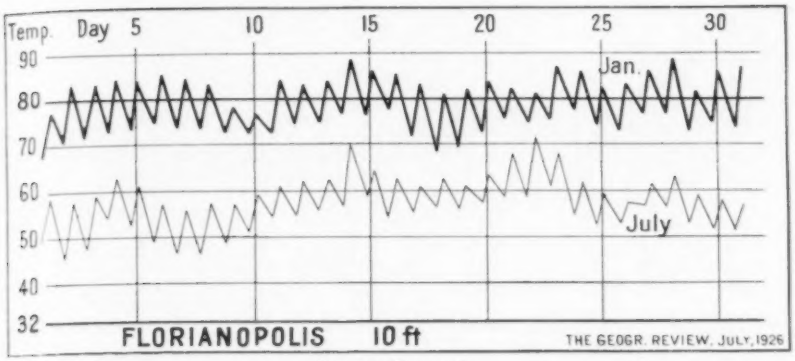


FIG. 16—Year 1916

January: mean 76°; range 10°; variability 3°; rainfall 4.3 ins.
July: mean 59°; range 8°; variability 3.3°; rainfall 3.3 ins.

appearance of spells of weather here, and we are beyond the southern tropic.

THE SOUTH OF BRAZIL

The southernmost of our Brazilian stations is the important city of Porto Alegre in Rio Grande do Sul, separated from the Atlantic by the Lagoa dos Patos and its bar. In summer it has hot days and mild nights; in winter the nights occasionally reach frost. It is a proper home of oranges, bananas, and palms with winters mild to cool. The thermometer is frequently in the nineties and once in January touched 100°. The variability and diurnal range are moderate, summer and winter are definitely separated, and there is a distinct appearance of spells of weather which we may now trace over into the Argentine Republic. A phenomenal cold spell occurred in

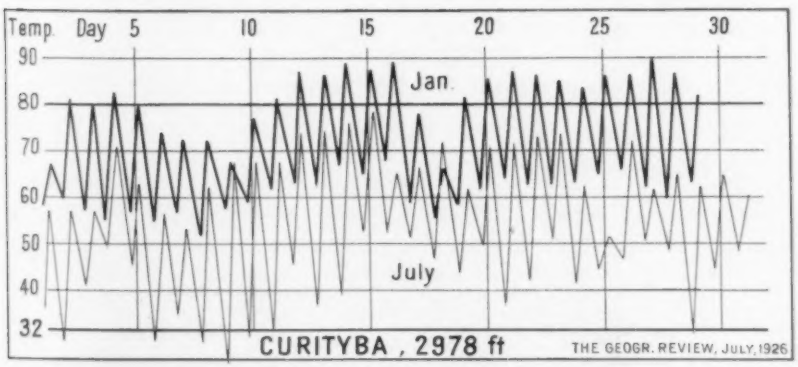


FIG. 17—Year 1916

January: mean 71°; range 20°; variability 4.3°; rainfall 4.4 ins.
July: mean 54°; range 21°; variability 5.3°; rainfall 2.7 ins.

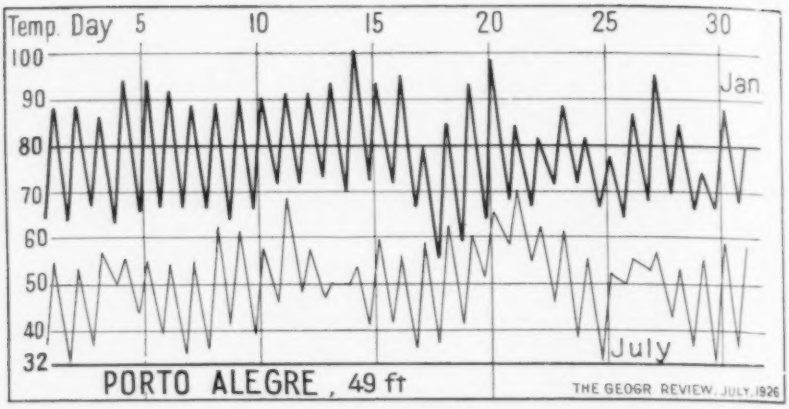


FIG. 18—Year 1916

January: mean 76°; range 23.6°; variability 3.6°; rainfall 4.0 ins.; relative humidity 71
July: mean 50°; range 16°; variability 3.3°; rainfall 3.3 ins.; relative humidity 86

July, 1918. Bananas about Porto Alegre were blackened by frost. Snow fell in Rio Cuarto, province of Córdoba, all day long. At Buenos Aires the snow lasted on shaded roofs for two or three days. The course of the temperature at Porto Alegre is shown in Figure 19. This is almost twice as great a fall as at Buenos Aires, where the maxima and minima of those days were:

1918, July	5	6	7	8	9
	55	43	44	52	53
	32	27	30	26	22

That amounts to a drop of 33 degrees. This is the same phenomenon noted at Corumbá and is what we might call the magnification of a cold spell as it passes into the tropics. On the morning of July 9 the water in the roadside ditches twenty miles inland from Porto Alegre was frozen strongly enough to support a stone as large as a man's fist. On the plateau in Paraná and São Paulo coffee plants were said to have been killed by thousands. One would have imagined the coffee industry was at an end! The spell was traceable at Rio, but

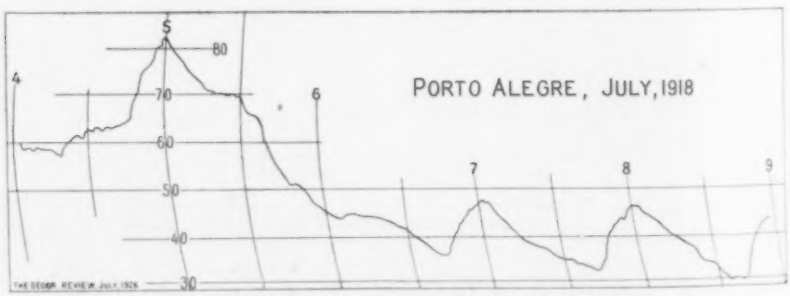


FIG. 19—Fall in temperature of 53°, July, 1918, at Porto Alegre

there the temperature merely dipped a little under 60°. The contrast between this diagram and that for Rio is striking. We are now out of the tropics.

The Northeastern Argentine

Nearly 350 miles west of Porto Alegre the south-flowing Uruguay separates Brazil from the Argentine Republic with the town of Uru-

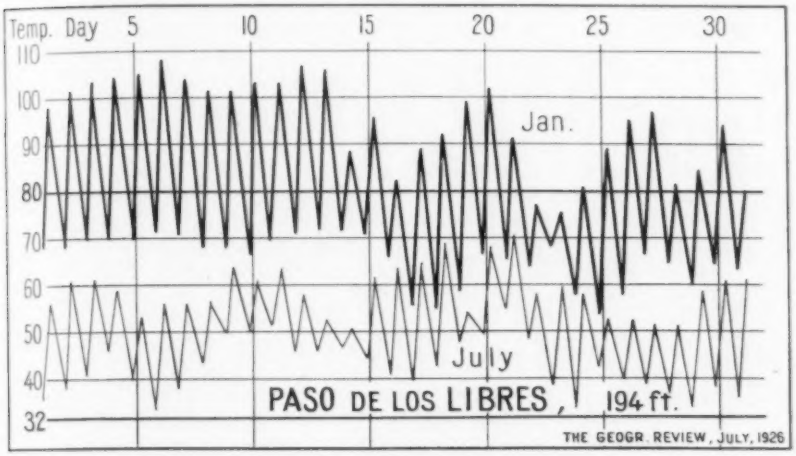


Fig. 20—Year 1916

January: mean 80°; range 28°; variability 6°; rainfall 6.9 ins.; relative humidity 62
July: mean 50°; range 17°; variability 3.5°; rainfall 5.1 ins.; relative humidity 78

guayana on the Brazilian side and, across the river on the Argentine side, Paso de los Libres (Freemen's Pass), suggestive of the old days of slavery in Brazil and freedom across the river. Paso is west of the Brazilian plateau and practically at the level of the Pampa.

Summer has more hours of sunshine—here measured at 248 in January and 153 in July—and a greater diurnal range. It also has more rainfall. The temperature march is in general similar to that at Porto Alegre. The difference is between the summer means and is mainly caused by hot afternoons at Paso in the first two weeks of the month, which were not matched at Porto Alegre. On those days the wind was rather steadily in the northeast, and the relative humidity at 2 p. m. was from 22 to 37, which is extraordinarily low. The fortnight had no rain and few clouds. From here we enter the Pampa region where there is much sunshine and the air is dry.

The Pampa

Characteristic temperatures for the Pampa are met at Córdoba at the western border. The city is situated much like Denver, at

the foot of a range of mountains on a semiarid plain. It is 1400 feet above the sea. In both January and July the air has the low humidity of 50 per cent and is as exhilarating as that of our High Plains. Summer and winter are quite distinct, the summer hotter and the winter colder than at any other point studied in this paper except Chicago. Snow falls but does not lie long on the ground. These are continental temperatures in largeness of range and variability. All the Pampa

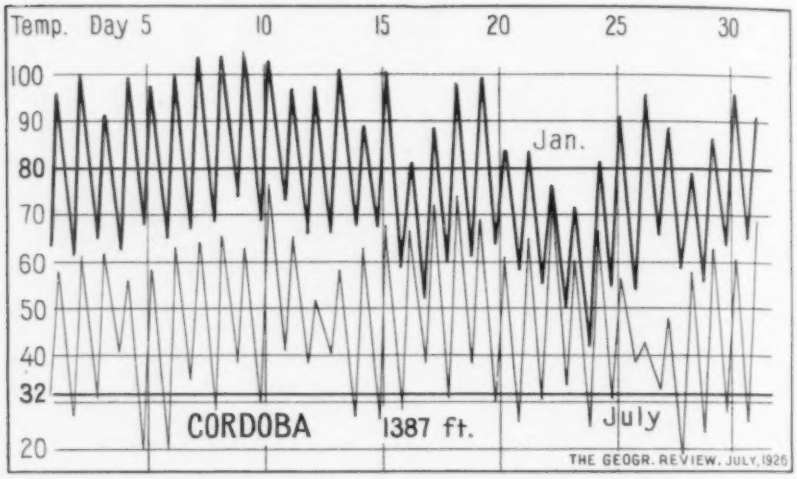


FIG. 21—Year 1916

January: mean 77.5°; range 31°; variability 5.7°; rainfall 2.7 ins.; relative humidity 51
July: mean 47°; range 32°; variability 3.4°; rainfall 0.0 in.; relative humidity 50

stations have most sunshine in the rainy summer season. At Córdoba the range is from 310 hours out of a possible 425 in January to 206 hours out of a possible 320 in July. The summer rains come in thunderstorms that often last less than an hour. Between the storms the sky is clear. That is remarkable for a rainy season. The rainless winter, on the other hand, has on an average only six or seven hours of sun a day, which was a great disappointment to the astronomer who selected Córdoba for an observatory because of the clear skies of its rainless winters. The summers at Córdoba are hot by day and mild at night, the winters mild by day and cold at night. There are distinct spells of weather, and a severe cold spell in winter among people living and working in unheated houses causes occasional periods of great discomfort. Business must suffer serious loss in Buenos Aires and Córdoba and other Pampa cities from the inability of clerical employes to work efficiently while shivering with cold.

A moister region is Tucumán, 300 miles to the north of Córdoba. It is the land of the cane sugar plantations—and malaria. The rainfall is abundant, and a tropical forest of walnut, laurel, cebil, and

lapacho clothes the eastern slopes of the 17,000-foot mountain mass of Aconquija. The heat régime is similar to that of Córdoba, but Tucumán is warmer by six or seven degrees. In this place the variability for summer has become twice as great as for winter, just the opposite of what occurs in the United States and at Cuyabá and Corumbá. The strongly marked cold spell of January 21, 22, and 23 accompanied the chief precipitation of the month when three-quarters

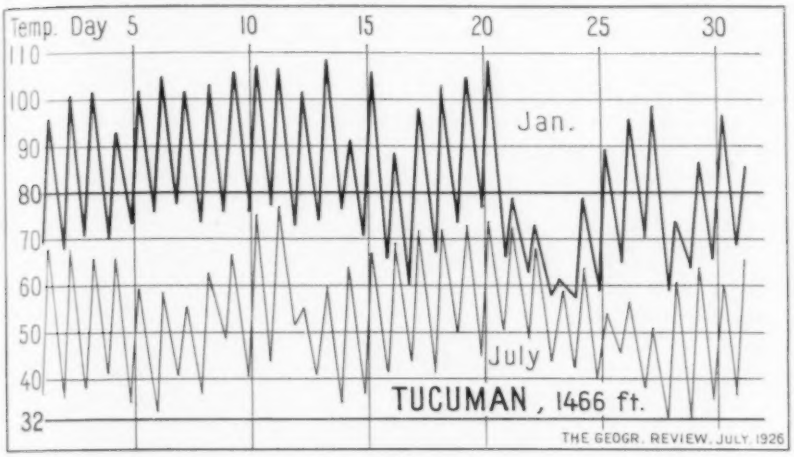


FIG. 22—Year 1916

January: mean 82°; range 25.5°; variability 7.3°; rainfall 2.9 ins.; relative humidity 67
July: mean 53°; range 24°; variability 3.9°; rainfall 0.0 in.; relative humidity 68

of the month's rain fell in the three days. The barometer on the 23rd was the highest of the month, except for the 28th, when there was another drop in the temperature accompanied by another shower. The writer lived in Tucumán for three years and recalls how impressively after a summer thunderstorm the clouds would roll away and reveal the whole upper mass of Aconquija deep in snow, of which only scattered lines and patches would remain in winter. The effect of these great snow fields on the temperature is strikingly shown by the graph. Such mountain snows must play a decided part in giving the summer variability its large value.

At Córdoba the mountains are much lower and carry no snow. But the same spell of January 21 appears on the Córdoba diagram with much less intensity. All three days at Córdoba were overcast, and on the 23rd a third of an inch of rain fell. Córdoba had its principal rain in that January on the 16th, a little more than half the month's total, with the barometer a shade below the average for the month. The change of weather shows on our diagram as a sharp drop in temperature. At Paso de los Libres most of the month's

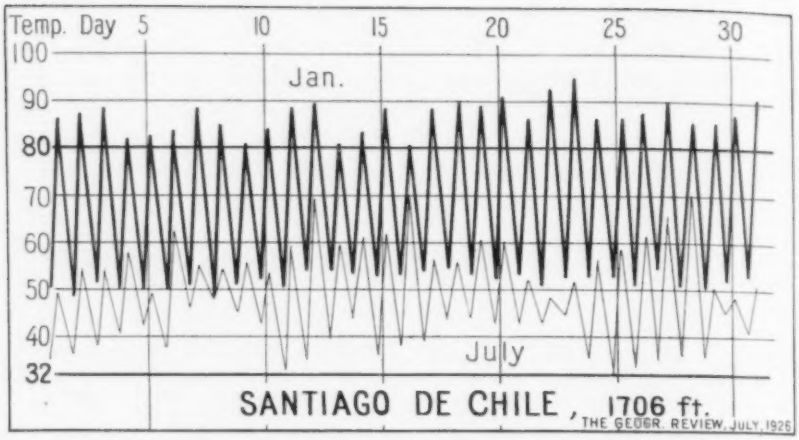


FIG. 23—Year 1913

January: mean 69°; range 34.5°; variability 2.2°; rainfall 0.0 in.
July: mean 48°; range 17.5°; variability 2.5°; rainfall 4.7 ins.

rain fell on the 20th, 21st, 22nd, and 23rd, beginning a day earlier than at Tucumán, although the cold spell began on the 21st at both places. The other January rains at Paso were on the 14th, 15th, and 16th, and on the 28th and 31st, in each case marked by a distinct fall of temperature. In all probability the severe cold at Corumbá is accompanied by rain. Everything goes to show, then, that summer variability is high at Tucumán because in this part of South America summer is the season of rainstorms.

Mendoza, 150 miles farther from the equator than Córdoba and a thousand feet higher above the sea, has a similar temperature régime, running three or four degrees cooler. Locally the Andes carry no large masses of snow but in this latitude are naked and barren on their eastern flanks. Mendoza has many a night of frost in winter. Summer is less dry than winter but is distinctly hot. On the July

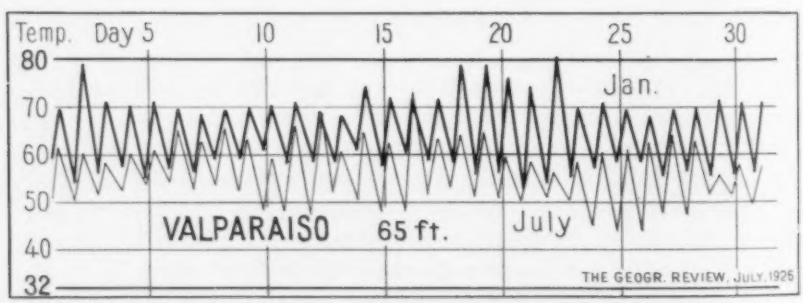


FIG. 24—Year 1913

January: mean 64°; range 14°; variability 1.4°; rainfall 0.0 in.
July: mean 56°; range 11.5°; variability 1.8°; rainfall 4.7 ins.

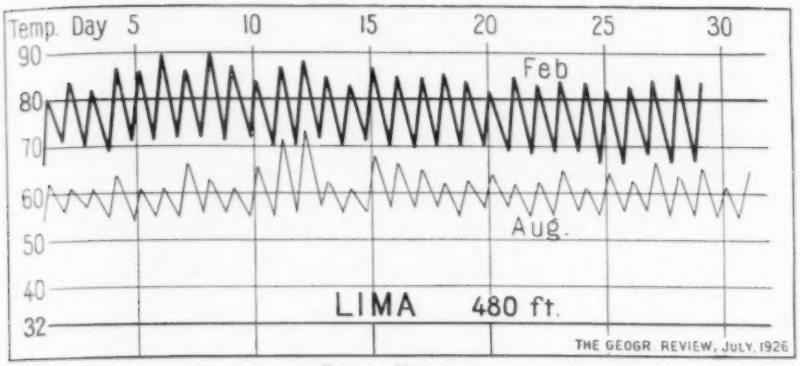


FIG. 25—Year 1912

February: mean 77°; range 15.5°; variability 1.4°; rainfall 0.0 in.
August: mean 60°; range 8.5°; variability 1.7°; rainfall 0.8 in.

25th cited, when Córdoba and Tucumán had cloudy skies which prevented insolation by day and radiation by night, Mendoza had a trifling fall of rain which became snow at sunset, with temperatures below freezing.

THE VALLEY OF CHILE

By air it is little more than a hundred miles from Mendoza to Santiago de Chile, but between the two places lies the great wall of the Andes with its lowest notches all above 12,000 feet. With the disappearance of summer rain the variability of summer has dropped to a half or a third of its Argentine values. Under the uninterrupted sunshine of summer skies the January temperature acquires extraordinary regularity. Santiago is enclosed in a pocket among the mountains. A coast range shuts it in from the Pacific. There is much clear sky and sunshine; hence the hot summer afternoons and also occasional winter frosts. Every night of January was within a degree or two of 52—delightful nights to sleep. One day was like another, with the tremendous range of 34 degrees from day to night. Winter

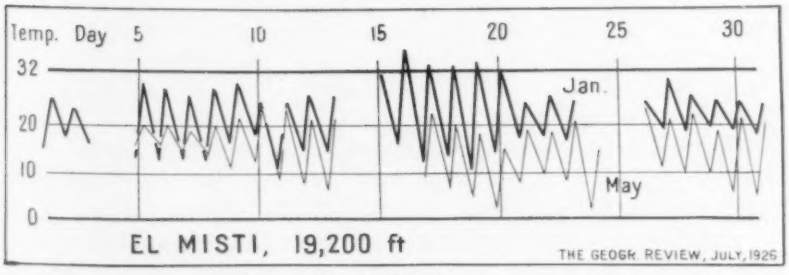


FIG. 26—Year 1894

January: mean 21°; range 12.5°; variability 1.3°
July: mean 14°; range 11.5°; variability 1.9°

has a greater variability, for then come the rains and accompanying clouds. There are rainy spells, of little diurnal range of temperature—the 5th, 7th, 10th, and 29th—but the variability is greater. We are now in the realm of universal winter rain, and north of Santiago summer has no rain at all. Farther north one passes rapidly to regions of less and less rain at any season.

The little village of Los Andes, north of Santiago, on the railway between Valparaiso and Mendoza, has almost the same temperatures

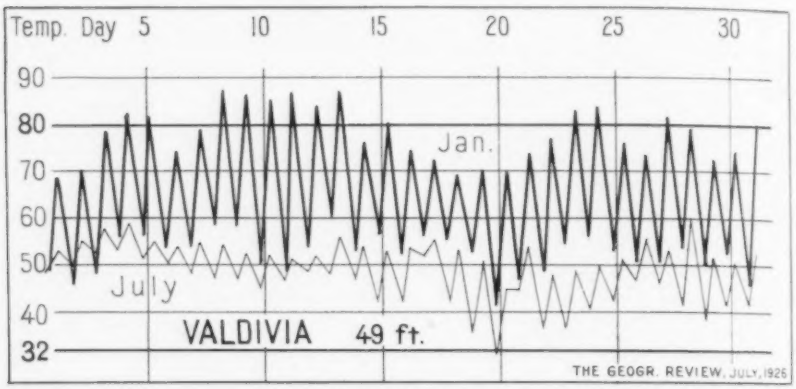


FIG. 27—Year 1913

January: mean 65.5°; range 25°; variability 3.5°; rainfall 0.2 in.
July: mean 49°; range 8°; variability 3°; rainfall 25.5 ins.

as Santiago, though it is a thousand feet higher. Summer has warm days and mild nights, and winter has mild days and mild-to-cool nights, the rains diminishing the daily range without much lowering the general temperature.

WEST COAST TEMPERATURES

It is of course not merely the Pacific Ocean that lies at the foot of the hills at Valparaiso, but the Humboldt Current, or rather those upwelling waters from ocean depths that maintain temperatures so monotonous from Mocha almost to the Gulf of Guayaquil. Under the evident influence of the ocean waters are Antofagasta, Iquique, Arica, Mollendo, and Lima. Of Pacific temperatures out beyond the Humboldt Current we may get some idea by the data for Easter Island, 2500 miles west of Chile and about 350 miles farther north than Valparaiso: January mean 72.5, range 11; July mean 63, range 8.5. This indicates no water from the depths.

Lima lies some seven miles from the ocean at the back of its fertile plain, unlike Valparaiso. It is within 800 miles of the equator and so is warmer—13 degrees warmer in summer. The heavy fogs that yield the precipitation of winter must be responsible for the cut in

the winter diurnal range to two-thirds of its value at Valparaiso. For the rest, sameness is the note. Neither Valparaiso nor Lima has temperatures below 45°. Summer afternoons at Lima range within two or three degrees of 83, and nights within a degree or two of 70, where Valparaiso has 70 and 58. They are 1500 miles apart. Other graphs for this coast merely repeat the same forms.

While this station and Mollendo, in the writer's earlier paper, illustrate fairly well the types of temperature variation at low levels

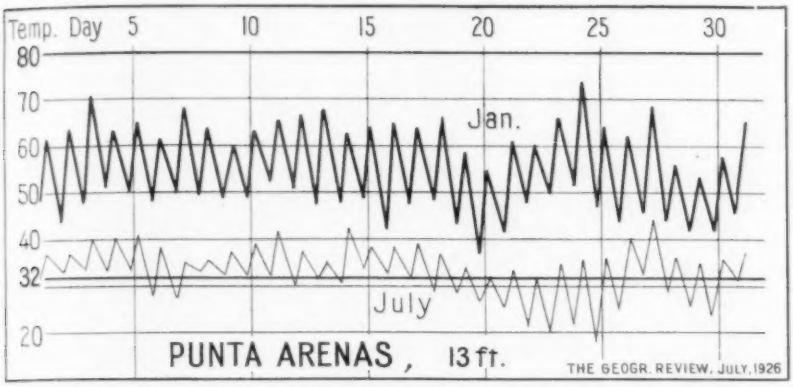


FIG. 28—Year 1913

January: mean 55°; range 15.5°; variability 2.7°; rainfall 0.3 in.
July: mean 33°; range 7.5°; variability 2.7°; rainfall 4.3 ins.

along the Pacific coast, a record obtained by the Harvard College Meteorological Expedition in 1894 gives a unique picture of what was going on at the summit of the 19,000-foot volcano Mistí, near Arequipa. The peak is above the lower clouds, the régime tropical in every respect, the greater variability of the winter suggesting that up there, too, precipitation occurs at that season. The moderation of the cold is surprising for the altitude. Chicago winter (January) temperatures ranged from −2 to 62. On El Mistí they ranged from 3 to 24. A letter from Professor Pickering of February 13, 1907, states that the minimum between 1893 and 1895 was −2. On January 7, 1878, Juan L. de Romaña climbed the mountain and found a temperature of −12. The observations used in our graph are thermograph observations made near the summit of the volcano, which was visited by mule train on occasion to change the record sheets and wind the clocks.

The uniformity of temperature régimes on the sunny Pacific coast ends at the little island of Mocha, 38° S. This is south of Chile proper, the sunny Chile of the Creoles. At Valdivia the rain amounts to an annual 108 inches. Valparaiso had but 21. Valdivia is ten miles from the sea, up the river of that name. The large diurnal

range of summer must correspond to clear skies at that season, unusually rainless in 1913 if our record is accurate. Seventy-one per cent of the year's rain usually falls in the six months of winter but January usually has two per cent and July has 15. Winter does not greatly differ from summer in temperature. The contrast is of hot days with mild nights and mild days with cool nights. Summer heat as great as 87° may be noted. Winter temperature does not often go below 40°, but frosts are known.

The Extreme South

The southernmost of the world's towns is the little city of Punta Arenas in the Strait of Magellan, east of the backbone of the Andes again, though the whole strait is Chilean—a Chilean hallway to a Chilean front door on the Atlantic. Punta Arenas is only as far south of the equator as Liverpool is north of it. The temperatures are not much harsher than those of British points. Liverpool mean temperatures range some five to six degrees higher. They are strongly affected by the ocean. "Spells-of-weather-oceanic" I would call its temperature, like British temperatures. Once we used the term "temperate-oceanic," but it is time the word "temperate" was definitely dropped as a name for the zone it miscalls.

Sufficient comment has been made on the temperatures studied as we have exhibited their data. I believe the diagrams published set forth all the principal types of weather found in South America as far as thermometric—not sensible—temperatures are concerned. The examples have been chosen from a much larger body of data, though there are none included from Venezuela, Colombia, Ecuador, the Guianas, Paraguay, Uruguay, or Bolivia. This study is based wholly on work accomplished by the industry and enterprise of the Argentine, Brazilian, and Chilean Meteorological offices, which have generously and courteously placed at my disposition whatever data I have asked of them. Where the data are incomplete or are not such as would have best illustrated the point, it is because I did not ask for the right material.

If I were beginning such a task again—and there are still four continents unstudied—I would attempt to get all the data for a single year and all for July and January everywhere, thus gaining a synoptic picture of actual weather over a wide area. It is evident that winds, rainfall, humidity, and clouds should be included in the record studied. It is impossible to study one element of the weather adequately without bringing in the others.

RECENT THOUGHT ON THE PROBLEM OF WHITE ACCLIMATIZATION IN THE WET TROPICS

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University of Wisconsin

WITHIN the past few years there has been a renascence of interest in the problem of white acclimatization and colonization in the wet tropics. One reason for renewed interest is the close relationship of acclimatization to world food supply in the face of increasing population. Fear that the time is not far distant when the arable lands of the intermediate zones will be unable to support the rapidly increasing white populations of the earth, directs attention to the sparsely populated tropics as potential sources of food and possibly also as a future home for surplus white peoples. To quote one of many similar expressions, "When the great valleys of the Amazon and the Congo are occupied by a white population more food will be produced in these regions than is now produced in all the rest of the inhabited world."[1]

William Z. Ripley, in his book, The Races of Europe, published in 1899, reviewed in a fairly thoroughgoing fashion the literature on acclimatization up to that date. He writes: "Summarizing the views of authorities upon this subject, the almost universal opinion seems to be that true colonization in the tropics by the white race is impossible."[2] For the literature on acclimatization which has appeared since 1899, the date of Ripley's book, no satisfactory summary in English existed until 1923, when Dr. Andrew Balfour, Director of the London School of Hygiene and Tropical Medicine, published in The Lancet three papers with bibliographies on that subject.[3] He states his own opinion as follows: "So far as the race is concerned I am persuaded that the hot and humid tropics are not suited to white colonization and never will be with our present knowledge, even if they are rendered as free from disease as England."

In the present paper the writer has attempted to summarize the trend of thought in the writings and research of recent authors on tropical acclimatization, almost exclusively those of the medical profession, for it is they who are best qualified to speak on the sub-

[1] General W. C. Gorgas, quoted in *Boston Medical and Surgical Journal*, Aug. 5, 1915, p. 220.
[2] W. Z. Ripley: The Races of Europe, p. 584, New York, 1899.
[3] Andrew Balfour: Sojourners in the Tropics, *The Lancet*, Vol. 204, 1923, pp. 1329–1334; *idem:* Problems of Acclimatisation, *ibid.*, Vol. 205, 1923, pp. 84–87 and 243–247.

ject. He acknowledges the considerable help he has obtained from Dr. Balfour's papers.

Much confusion is apparent throughout the literature on acclimatization as a consequence of lack of definition relative to the meaning of that term. In the present discussion true acclimatization will be understood to involve the following requirements:

1. That peoples of the white race in large numbers shall be able to go into the wet tropics and there live on a plane of civilization similar to that at home, retain their original physical health and vitality, mental and moral vigor, and perpetuate their kind.

2. That the future generations begotten by these tropical immigrants shall maintain a civilization at least the equal of that in the homeland and possess the equivalent in length of life, moral character, physical stamina, and mental alertness of that possessed by their intermediate-zone ancestors.

The numerous types and gradations of tropical climate seriously interfere with our arriving at any general conclusions for the low latitudes as a whole. Each type presents its own advantages and handicaps to the would-be white settler. In the drier phases, lack of an adequate water supply for crops places a serious limitation upon agricultural development. It is the constantly wet type which, climatically at least, seems to hold the greatest possibilities for food production. It is specifically with the rainy low-latitude type of climate, therefore, typified by conditions in the basins of the Amazon and the Congo, and possessing, probably, not only the greatest potential agricultural resources but likewise the most serious handicaps to permanent white settlement, that this paper is concerned.

The problem of acclimatization will be discussed under the following heads:

1. Disease and other indirect climatic influences of a harmful nature in the wet tropics.

2. Physiological, pathological, and psychological effects of a hot humid climate upon white men.

3. Historical evidence for and against acclimatization.

Disease in the Tropics

A review of the non-medical literature, at least, and even some of that which has come from the pens of men trained in medical science, reveals a growing optimism concerning the future of the white race in the wet tropics. If the malign influence of the low latitudes is confined to the disease concomitants of climate, and if disease is the only real curse of the tropics as some believe, then certainly there is some foundation for this optimism. Tremendous

strides have been made in the war on tropical diseases, and the success of modern sanitation and hygiene in the tropics has raised high the hope that life may be made as safe in the regions near the equator as it is in our latitudes.

The peoples of the intermediate zones, through costly experience in the past, had come to fear and dread the tropics. The colonial histories of European nations operating in the wet tropics are not wanting in tales of the devastating and scourging effects of tropical disease. A French force of 25,000 men in Santo Domingo in 1798 is reported to have lost 22,000 by the ravages of yellow fever. The first English settlement in Sierra Leone in 1787 was nearly annihilated by disease,[4] and in England "the white man's grave" became a synonym for the British West African colonies. As late as 1890 the French were frustrated in their attempt to build a Panama Canal through the toll of lives taken by malaria and yellow fever. The long sick lists and high mortality rates, resulting from disease among our own troops campaigning in Cuba during the Spanish-American War testifies that even at the beginning of the twentieth century tropical diseases remained much of a puzzle.

But, it is said, medical science has conquered this situation. The work of Gorgas at Panama is pointed out as an object lesson in successful tropical prophylaxis, the death rate there being reduced from 40 per 1000 in 1904 to 7.5 per 1000 a year or so later. Similarly the work of Gorgas and Wood at Havana, of Connor at Guayaquil, of Cruz, Ribas, and Lacerda at Rio and Santos are monuments of victory. The death rate among British soldiers in India has been reduced from 70 per 1000 to less than 5 per 1000. In the Malay States alone during 19 years, it has been estimated that 32,000 lives have been saved by the reduction of the death rate following adequate drainage. Half a century ago the death rate of Jamaica rarely fell below 50 per 1000, whereas at present it is about 20 per 1000 or a little more.

In comparison with former times, therefore, a considerable improvement is noticeable in the general sanitary conditions of tropical countries. "No wonder that the pessimistic criticisms of yore have already undergone a considerable change and are even in a fair way to be replaced by rather too optimistic views. Malaria, yellow fever, cholera, dysentery, plague, beri-beri—those scourges of the tropics, are all, it is argued, avoidable diseases, avoidable because science has discovered their causes and thus provides the means of combating them with success." So take away the diseases and there will remain the healthy inhabitant of the tropics. Such optimism is not entirely warranted.

[4] Andrew Balfour and Henry Harold Scott: Health Problems of the Empire Past, Present and Future (Series, The British Empire, edit. by Hugh Gunn, Vol. 4), London and New York, 1924, p. 74.

Malaria still remains probably the most destructive disease of the world, taking a toll of approximately 2,000,000 lives each year.[5] Ronald Ross of the Bengal Staff Corps, who was awarded the Nobel Prize in recognition of his discovery of the rôle of the mosquito in malaria dissemination, stated that one-third of the population throughout the tropics suffer from that disease every year and that it was the cause of about one-third of all the attendances at hospitals in the tropics.[6] Compared with yellow fever the fight against malaria is much more difficult, for while only one species of mosquito is capable of conveying yellow fever, there are a score or more (of the group Anopheles), each one with different habits, that transmit the germs of malaria. But in spite of the difficulties, progress in malaria eradication is slowly being made in certain focal centers. As Balfour and Scott point out, however, the question always asked must be, "Is the game worth the candle?", for a general prophylaxis campaign against malaria is an expensive undertaking, and in some regions the benefits to be gained from such a campaign will not, at the present time at least, justify the expense. This is probably true in parts of the wet tropics.

Tropical dysentery slays outright and makes miserable wrecks of white men in the tropics, and the treatment of that disease in its chronic form remains an enigma. Excluding venereal diseases, hookworm, and malaria, dysentery is the greatest burden upon the welfare and resources of the British Empire.[7] Relief is possible only through expensive sanitary procedure, for no therapeutic is known.

Sleeping sickness, which in the last century was rather localized within the Dark Continent, has spread, owing to better communication. "It now occurs over a vast area of equatorial Africa, causing a high mortality and a considerable diminution in the birth rate, thus seriously threatening the existence of a whole race. Labour has become scarce, and this is having an effect on the economic development of the whole country. . . . The campaign is being conducted with energy by the various governments, but the immensity of the infected area and the great distances which separate the various groups, are serious obstacles against which only a small number of doctors are available."[8] In spite of the considerable work that has been accomplished, much about the disease still remains unknown. The drugs used at the present time have only sterilization properties, for no therapeutic has been discovered.

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[5] F. F. Russell: War on Disease, Particularly Yellow Fever and Malaria, *Sigma Xi Quart.*, Vol. 13, 1925, pp. 29–32.

[6] Ronald Ross: Memoirs, with a Full Account of the Great Malaria Problem and Its Solution, London, 1923, p. 115.

[7] Balfour and Scott, *op. cit.*, p. 206.

[8] Andrew Balfour, E. van Campenhout, Gustave Martin, and A. G. Bagshawe: Further Report on Tuberculosis and Sleeping-Sickness in Equatorial Africa, in "Health Document of the League of Nations," April, 1925, Appendix B, p. 69.

Hookworm in consequence of its enfeebling and enervating effects constitutes a genuine blight throughout much of the tropics. Balfour and Scott speak of it as "The Imperial disease par excellence, for even malaria does not, day in and day out, produce such a heavy economic loss." It has been estimated that 90 per cent of the people between sea level and 3000 feet elevation in Colombia are infected with hookworm; the same degree of infection is probably true in Ceylon; while of the 300,000,000 people in India 60 to 80 per cent harbor the parasite.[9] Eradication of hookworm is within the bounds of possibility, but it can never be satisfactorily achieved in the tropics until the native populations have been educated along sanitary lines; and that is not likely to be an immediate accomplishment.

It should be emphasized also that statistics of death rates in the tropics are usually not a true index of the health conditions prevailing there, for many of the tropical diseases, while not highly fatal, result in a weakening and debilitation of the victims which is responsible for loss of will power, intemperance, and general physical mental and moral degradation. For every one who dies of malaria or hookworm, two or three hundred may be ill with these maladies, and the number of sick days resulting is a frightful handicap to any community. Managers of coffee haciendas in Porto Rico estimate that the efficiency of labor on their plantations is reduced 35 to 50 per cent by hookworm. A certain Dr. Parker reports that on a visit to one of the largest cacao plantations of Ecuador he found hookworm and chronic malaria made available not more than one-third of the laborers at that place.[10] Managers of the tea estates in the Darjeeling region estimate that the Rockefeller anti-hookworm campaign has increased the labor efficiency of coolies from 25 to 50 per cent.[11]

What then is a reasonable attitude toward tropical diseases as one of the acclimatization problems? It must be admitted that they are still one of the serious handicaps to a white invasion of the low latitudes. Notwithstanding the epoch-making discoveries of science with respect to the origin of these diseases and the methods of combating them, as well as the highly successful campaigns that have been waged against some of them in certain centers, their complete eradication throughout the whole of the low latitudes, and especially the constantly wet tropics, cannot be expected in the near future.

Much further investigation is necessary on the part of medical science before effective attacks can be launched against the strongholds of some of the tropical diseases. It seems probable that widespread sanitary campaigns will be the only means of successfully

[9] "Hookworm Infection in Foreign Countries," *Rockefeller Sanitary Commission for the Eradication of Hookworm Disease, Publication No. 6*, Washington, 1911, pp. 4 and 5.

[10] *Ibid.*, p. 5.

[11] Balfour and Scott, *op. cit.*, p. 194.

routing a number of them; and sanitation in the humid tropics is not only expensive, in places prohibitively so, but likewise tremendously difficult because of the ignorance of the natives. Those who are most actively engaged in the war against tropical disease are not given to exuberant optimism concerning the outlook but are preparing for a conquest "which must be sustained with method and tenacity" for years to come. Gorgas' work at Panama was accomplished only by a large expenditure of money on a limited area, backed by a rigorous and compulsory procedure of sanitation. Such methods cannot as yet be applied to the wet tropics as a whole.

Numerous other handicaps, only indirectly climatic in their origin, such as tendency toward excessive use of intoxicating liquor, altered social state, close association with so-called inferior races, with the temptation to sexual indulgence which this situation makes possible, distaste for physical exercise, and the difficulty of obtaining a correct and balanced diet make normal healthy living among whites in the tropics a difficult problem. Most of these handicaps, it is pointed out, are amenable to correction; yet, like tropical diseases, they are very real problems to white settlers and cannot be lightly dismissed.

Physiological, Pathological, and Psychological Effects of Tropical Climates

The evidence at hand concerning the effects of wet tropical climate upon the physical bodies of white people is conflicting and incomplete as yet. Further investigations along these lines will no doubt provide us with useful conclusions regarding white acclimatization.

General metabolism and heat production. It was formerly maintained that inhabitants of warm climates, both black and white, have a much lower basal metabolism, or heat production, than do the inhabitants of the higher latitudes. This automatic chemical regulation of heat production was thought to represent an adaptation to climatic conditions and to constitute an advantage in the struggle against high temperatures and humidity. Dr. Eijkman, Professor of Hygiene and Microbiology at the University of Utrecht, has recently presented what is apparently indisputable evidence in direct contradiction to the earlier view. He finds no difference as regards metabolism and heat production between hot and cold areas or between the white and colored races.[12] This has been verified only for a state of bodily rest and light to moderate work. Experiments showed that hard labor as measured by oxygen consumption is performed less economically at high temperatures, and this may contribute to earlier fatigue. Experience seems to show that the European cannot carry

[12] C. Eijkman: Some Questions Concerning the Influence of Tropical Climate on Man, *The Lancet*, Vol. 206, 1924, pp. 887–893; reference on p. 889.

on sustained heavy muscular labor in the wet tropics, and this may be a clue to the explanation of that shortcoming.

Heat regulation. If, as Eijkman seems to show, the white man's body does not in an automatic chemical way limit heat production in the tropics, except perhaps through lessening muscular activity, then maintenance of normal body temperature must be regulated by heat loss, largely through the skin. He believes that one of the differences between the colored and the white races is to be found in the functions of the skin. The pigmented covering arrests more thoroughly the rays of sunlight which might have an injurious chemical effect. The negro is thereby immune from sunburn and can go naked and so get the full benefit of the cooling power of the air.

Furthermore, the protective pigment allows with impunity the epidermis of the black man to be thinner than is the case in the less well protected white. Thus the loss of heat by conduction and radiation through the negro's skin is less difficult. Eijkman has shown by experimentation that there is a real difference between the white and colored races in the manner of heat loss. In the case of the European, with his thicker epidermis, the heat loss by evaporation of sweat may be slightly greater than in the Malayan; while the colored man, with his thinner skin, loses more by radiation and conduction.[13] The white man sweats profusely in the tropics; sweat literally drops from him, while the dark skin shows a fine velvetlike layer of perspiration, which permits the maximum in evaporation and acts as an efficient reflector of the sun's energy. This hypersecretion of the white is useless, for it deprives the body of water and weakens it. Thus the brown man is superior to the white in his economy of sweating.[14]

But, while pigment is perhaps an advantage in halting the lethal rays, an extra tax is placed upon the heat-regulating apparatus through the greater absorption of the sun's rays by the black skin. This disadvantage is partially compensated for by the increased dilation of the cutaneous capillaries, which tends to promote heat loss. The earlier belief in the superior radiating powers of the black skin has been proved experimentally by Eijkman to have no scientific foundation.[15]

The difficulties involved in heat loss in the wet tropics place a very definite limitation upon physical labor. With a heat engine that is constantly generating energy at a given rate and a surrounding environment that tends to retard the loss of heat, the problem of how to keep cool is serious even when one is at rest. Muscular activity increases the heat output and thus for the sake of comfort and health

[13] *Ibid.*, pp. 890–891.

[14] Quoted by Dr. Leonard Hill in "The Science of Ventilation and Open Air Treatment, Part II," *Medical Research Council, Special Report Series, No. 52*, London, 1920, p. 96.

[15] Eijkman, *op. cit.*, p. 890.

is to be avoided. Dr. Kipping of the Physiological Institute at Hamburg University concludes that for any climate the maximum safe output of work is a function of the drying power of the air in relation to its temperature and its rate of movement.[16]

Respiration, Blood, Digestion, and Excretion.[17] Respiration is normally less frequent in the tropics, even though the air is somewhat rarer and as a consequence contains less oxygen per unit volume than the cooler air of the higher latitudes. As a result of fewer respirations as well as the less oxygen inspired, less carbon dioxide and water vapor are given off by the lungs. Thus there is a greater retention of carbon dioxide in the blood, which, it is conceivable, may hasten fatigue.[18]

According to Balfour there is doubt as to whether climate alone can produce any change in the formed elements of the blood, and the testimony of the best authorities substantiates this view. Eijkman's investigations relative to the number of red blood corpuscles, haemoglobin content, specific weight of blood, its water content, and osmotic pressure indicate that there is no appreciable difference between natives and whites in these respects. There is no unanimity of opinion however. Little is known regarding the possible chemical changes induced by climate. Dutch physicians have noted a comparatively higher sugar content in the blood of Europeans in Java. This condition they ascribe to high temperature and humidity. The total fat content is likewise somewhat higher in Europeans than in natives, but the origin of this condition is only one of the many unsolved problems confronting the biochemist.

Tropical climate at first stimulates digestion and the digestive functions, but the effect is temporary and is soon followed by a diminution in appetite and some lowering of digestive activity. Dyspepsia and impaired digestive functions may lead to abnormal decomposition of protein bodies in the intestinal canal, and there ensues a pathological condition marked by chronic poisoning. Dr. Ross suggests that intestinal troubles may be at the bottom of much of the tropical neurasthenia.

Kidney excretion is decreased in amount in the tropics, but there is disagreement as to whether a greater concentration may not allow the same amount of waste material to be eliminated, though the effect of concentrated waste upon the kidneys themselves must be considered.

Generative functions and growth. Growth is more rapid in hot countries, and puberty is attained at an earlier age; but decline is more rapid as well. Balfour speaks of the "weedy" European children

[16] Quoted in a communication to *The Lancet*, Vol. 206, 1924, p. 51.

[17] See Balfour, in *The Lancet*, Vol. 205, 1923, pp. 86–87, for detailed discussion and reference to authorities.

[18] *Ibid.*, p. 86.

in the tropics. Greater generative vigor is present in both sexes in the tropics, but excessive sexual indulgence is more likely to result in exhaustion and neurasthenia than it is in cooler climates. Dr. Leonard Hill is of the opinion that tropical conditions lessen the fertility of European women, but the evidence is not conclusive. Lenz, writing in 1921 on the neurasthenia of East African natives, expresses his belief that act of will depends upon a hormone supplied by the germ glands and that a tropical climate checks its development.[19] Certainly this is only an hypothesis, but it is an interesting suggestion in the light of recent discoveries concerning the importance of internal secretions.

Nervous system. It is upon the nervous system of the white man that the strain of tropical climate seems to tell most effectively, and it is this system which a number of eminent medical authorities believe presents the greatest barrier to white colonization. The effects of tropical heat and humidity produce a condition known as neurasthenia, "a complex of symptoms produced by nerve exhaustion, and associated with if not causing, an alteration in bodily nutrition." It does not directly kill the patient, but through weakening his will power, sapping his energy, decreasing his power of concentration and creating an emotional condition of irritability and depression it makes him unfit for a position of trust and responsibility. Of tropical neurasthenia Professor Eijkman writes as follows, "Health is not a mere negation of illness, it also implies something positive. The full use and control of the mental and physical functions, a vigorous constitution, a considerable amount of bodily well being—those characterize the healthy man. Much of this the sojourner in the tropics lacks, though he may be exempt from illness."[20] Sir Havelock Charles, President of the Medical Board of India, writes: "It is this terrible nerve exhaustion which has, in the past, been the most important factor in preventing the northern races settling, and procreating their line, with a full share of the nerve vigour which the parental stock possessed."[21]

The definite physical cause of tropical neurasthenia, medical science has not been as yet able to discover. Whether there is a direct demonstrable pathological effect of tropical climate upon nerve tissue is not known. It may be induced in indirect ways through affecting those systems subservient to the nervous system. Because it has thus far been impossible to attach a definite cause to tropical neurasthenia, as has been done to most tropical maladies, many have come to think of the enervating and depressing influence of humid heat as something of a myth. It is significant in this respect that

[19] Cited by Balfour, *ibid.*, p. 243.

[20] Eijkman, *op. cit.*, p. 887.

[21] Sir R. Havelock Charles: Neurasthenia and Its Bearing on the Decay of Northern Peoples in India, *Trans. Soc. of Tropical Medicine and Hygiene*, Vol. 7, 1913, pp. 2–31; reference on p. 11.

the Dutch Indies Civil Service Report for 1920 states that out of 189 cases of disease on account of which leave was granted, no less than 111 were examples of psychoses or psychoneuroses.[22] The physiology of fatigue, which has such an important bearing upon white neurasthenia in the tropics, is largely an unexplored field.

The increasing number of institutes and schools of tropical medicine which are being established gives rise to a hope that the coming years will show an accelerated research in tropical medicine and that definite conclusions can be substituted for some of the suggestions and much of the fiction that now exists regarding the effects of tropical climate. Climatologists, geographers, sociologists, and others must await the verdict of medicine before trustworthy conclusions can be drawn.

From the standpoint of our present knowledge of the definite physiological effects of tropical climate it would seem that acclimatization consists rather in an external than in an internal process—of making the manner of living in the tropics conform to the climate rather than expecting internal bodily adjustments. " . . . The native's frugality both in respect to food and drink, his, as a rule, calm, resigned view of life, his rule of *festina lente* would deserve, from a purely sanitary standpoint, to be set as an example to the white sojourner in the tropics. . . . " But this would be at the expense of his being no longer the pushing power necessary for the development of the tropics and does not conform with the strict definition of acclimatization as stated earlier in this paper. The colored man should not be thought of as immune to the discomforts of heat and humidity; he suffers from them as well but, to be sure, not to the same extent as does the white man. To become like the negro in his greater immunity to tropical heat, humidity, and disease is desirable, but if it is to be gained at the expense of sacrificing those qualities which are the white man's chief claim to distinction, it is of doubtful value.

The Historical Evidence

The historical evidence commonly cited for and against acclimatization is of two kinds. One group of writers attempts to show that important civilizations have in the past existed in the wet tropics, as proved by architectural remains. The sculptured temples of Cambodia, Java, and India are pointed to as concrete examples, while the remains of the highest indigenous civilization in the New World, that of the Mayas, are found in the jungle lowlands of Central America. From this evidence the argument is established that wet tropical climate, as such, does not militate against high cultural attainments.

[22] Cited by Balfour, in *The Lancet*, Vol. 205, 1923, p. 245.

Herbert Spinden insists that "the most stupendous manifestations of the physical and mental energy of man are found in the tropics, and the evidence shows that this energy was continued over stretches of many centuries."[23] He believes the exhaustion of these civilizations was due to disease rather than to climate as such. Some of the examples cited by this group still remain much of a puzzle, for the explanations of these apparent anomalies offered by those who insist that no good thing can come out of the wet tropics are quite as difficult to understand as the anomalies themselves.

The other group, which draws its evidence largely from the more recent historical record, finds little that can lead to an optimistic attitude as to the development of white civilizations in the wet tropics. The enumeration of the efforts at white colonization in the low latitudes is for the most part a continuous tale of misery. In spite of the fact that tropical colonies of European nations have been in existence for centuries, there is not a single instance of any one of them becoming the permanent home of a large white agricultural population. Huntington is responsible for the statement that there is almost no such thing as a fourth generation of Indian-born Englishmen in India. Even today, after more than a century and a half of supervision, the English are a mere handful of people going there on business, whether they are officials, merchants, or missionaries. The Dutch in Java are there in the same capacities and at the present time number less than 125,000, or only two-fifths of one per cent of the population.

But, although there is seemingly no clear-cut example of successful white colonization, past or present, in the wet tropics, that fact can scarcely be invoked to prove that it will not be accomplished in the future as the necessity for food and room becomes greater. The historical record does indicate, however, that the humid tropics possess an unfavorable environment, in which the white man does not choose to live without compelling force of circumstances.

Summary

There exist at the present time two distinct schools of thought with regard to the future of the white man in the tropics.

1. There are those who believe that the ill effects of tropical climate are due to the various concomitants of climate, disease, proximity of inferior races, drunkenness, etc., and not directly to the climatic elements themselves. These factors are admitted to be handicaps to a successful white invasion of the wet tropics, but they are probably not insurmountable ones and will eventually yield before the ad-

[23] H. J. Spinden: Civilization and the Wet Tropics, *World's Work*, Vol. 45, 1922–23, pp. 438–448; reference on p. 443.

vancement of science and the demands of mankind for tropical products. Within this group are conservatives and optimists, or those who see the influence of these secondary climatic factors operating as serious handicaps for many years to come and those, on the other hand, who believe that the conquest of the wet tropics by white colonists is imminent.

2. The second school believes that, with our present knowledge at least, true acclimatization is impossible. The advocates of this view, while admitting that, with due precautions, the white man individually can exist in the tropics, assert that racially he cannot persist. If all of the so-called indirect climatic handicaps are overcome, there still remains the direct influence of tropical sun, heat, and humidity which act upon the white man's body and more particularly his nervous system in such a detrimental way as to bring about a debilitated, neurasthenic condition. While admitting the neurasthenia, the first school takes issue with this latter group with respect to its direct climatic origin. This dispute can therefore be solved only by further research along the lines that it is proceeding at the present time, i. e. the pathological and physiological effects of heat and humidity.

TIDES IN WELLS

Paul Schureman

U. S. Coast and Geodetic Survey

WHILE the tides of the oceans have been the subject of considerable study because of their importance to navigation and engineering work, very little attention has been given to tides in wells on the land. In fact, it is probably not generally known that such tides exist. The phenomenon, however, had been noted by scientists many centuries ago. Pliny the Elder, in the first century of the Christian era, wrote in his Natural History on the phenomenon of tides, and the following quotation is from Bostock and Riley's translation of that history:

> At Gades [Cadiz, Spain], which is very near the temple of Hercules, there is a spring enclosed like a well, which sometimes rises and falls with the ocean, and, at other times, in both respects contrary to it. In the same place there is another well, which always agrees with the ocean. On the shores of the Baetis [Guadalquiver River] there is a town where the wells become lower when the tide rises, and fill again when it ebbs; while at other times they remain stationary. The same thing occurs in one well in the town of Hispalis [Seville], while there is nothing peculiar in the other wells.

In more modern times references are occasionally made to tidal fluctuations in wells situated near coasts. Not only shallow wells but artesian wells exhibit this phenomenon.

The Longport Well

Probably the most systematic observations of tides in a well which have ever been undertaken are those now being made in a well at Longport, N. J. These observations are being obtained through a coöperative arrangement between the New Jersey Department of Conservation and Development and the U. S. Coast and Geodetic Survey, in connection with an investigation of ground water conditions by the State of New Jersey and the U. S. Geological Survey, Mr. David G. Thompson, Associate Geologist, being in charge of the work.

Longport is at the southern end of a strip of land extending southwestward from Atlantic City, with the Atlantic Ocean on one side and Risley's Channel on the other side. The well, which is the property of the Borough of Longport, is known as the Fourteenth Avenue Well and is located near Atlantic Avenue about midway between Thirteenth and Fourteenth Avenues. The tidal waters of Risley's

Channel are about 75 feet to the northwestward, and the open ocean is about 500 feet to the southeastward.

The well was drilled in 1895 and is 803 feet deep. It is six inches in diameter at the top and has 50 feet of four-and-a-half-inch strainer at the bottom. When the well was first drilled, the water rose to a height of 14 feet above the surface of the ground; but later, because of the heavy pumping from other wells in Atlantic City and vicinity, the water level has receded and is now more than 20 feet below the ground level. There has been no pumping from the Fourteenth Avenue Well since the tide gauge was installed, the nearest pumping well being about one mile to the northeast.

A U. S. Coast and Geodetic Survey portable automatic tide gauge[1] was installed in the well on March 12, 1925. For some weeks previous to this a Gurley recording gauge had been used. The Coast and Geodetic Survey tide gauge was used until July 28, 1925, when it was replaced by a Friez gauge; but in the early part of November, 1925, the Coast and Geodetic Survey gauge was again installed. This gauge automatically draws a continuous record of the tide in the form of a curve.

Tidal Results

From a reduction of these observations the following results have been obtained:

Table I—Tidal Results, Fourteenth Avenue Well, Longport, N. J., April, 1925, to March, 1926

Month	High-Water Interval, Hours	Low-Water Interval, Hours	Mean Range, Feet	Mean Surface Below Sea Level, Feet
April, 1925	7.43	1.26	2.18	15.28
May "	7.34	1.19	2.20	16.61
June "	7.43	1.31	2.25	21.75
July "	7.50	1.40	2.30	26.86
August "	7.37	1.24	2.39	30.37
September "	7.49	1.24	2.39	31.49
October "	7.51	1.29	2.40	27.01
November "	7.43	1.15	2.26	23.97
December "	7.37	1.24	2.27	22.57
January, 1926	7.36	1.17	2.26	22.25
February "	7.33	1.10	2.27	21.95
March "	7.33	1.13	2.27	22.23
Means	7.41	1.23	2.29	23.53

In the first column of figures there are given the average monthly intervals between the times of the transits of the moon and the following high waters in the well. In the next column similar intervals for

[1]This gauge is described in Special Publication No. 113, of the U. S. Coast and Geodetic Survey.

the low waters are given. These intervals are expressed in hours and decimals. Following the intervals there is given the mean range of the semidaily tide for each month, this range being obtained by subtracting the average height of all the low waters from the average height of all the high waters occurring during each month.

In the last column is shown the depression of the mean surface of the water in the well below mean sea level. During the period of ob-

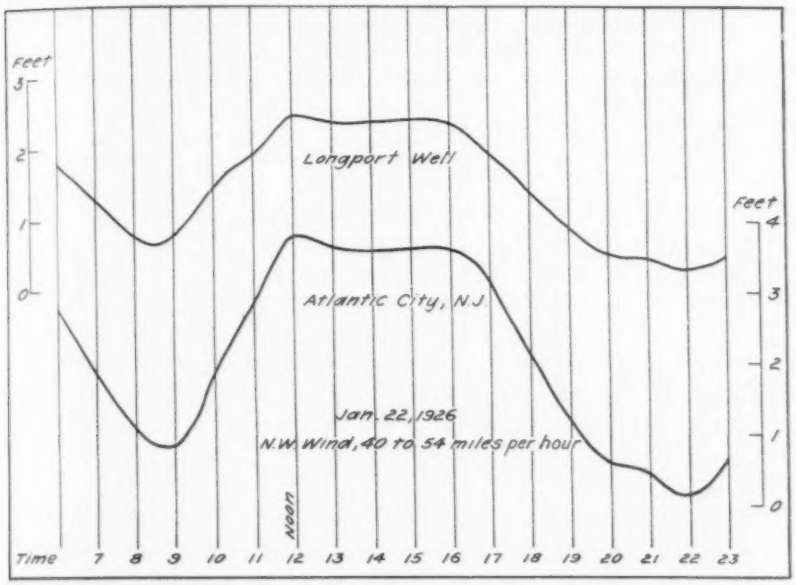

FIG. 1—Comparison of tide in well at Longport and in open ocean at Atlantic City during very strong northwest wind.

servations the water in the well was highest in the month of April, 1925, when the average level was 15.28 feet below mean sea level, and lowest in the month of September, 1925, when the average level was 31.49 feet below mean sea level, giving a difference of a little more than 16 feet. It is of interest to note that, notwithstanding this large difference in the surface level of the water in the well, there was very little difference in the times of the high and low waters as indicated by the high-water and low-water intervals. In fact, from an examination of the above table, it does not appear that the times of the high and low water in the well are affected at all by the fluctuations in the mean level. While the mean ranges of the tide for the months of very low water appear to be a little greater than the ranges for the months of higher level, this can hardly be attributed to the fluctuation of the water in the well, since there were corresponding variations in the ranges in the open ocean for the same months.

Comparison with Tides in Open Ocean

The U. S. Coast and Geodetic Survey maintains a principal tide station on the Atlantic City Steel Pier and it will be interesting to compare the results obtained from this station for the same months during which the observations have been made in the Longport well. The Atlantic City Steel Pier is about seven miles to the northeastward of the Longport well.

Table II—Tidal Results, Atlantic City Steel Pier, April, 1925, to March, 1926

Month	High-Water Interval, Hours	Low-Water Interval, Hours	Mean Range, Feet	Mean Level Referred to Sea Level, Feet
April, 1925	7.11	1.03	4.06	− 0.06
May "	7.12	0.91	4.11	+ 0.02
June "	7.12	0.94	4.16	− 0.02
July "	7.20	1.06	4.17	+ 0.06
August "	7.13	1.02	4.26	+ 0.08
September "	7.22	1.02	4.24	+ 0.26
October "	7.24	1.18	4.31	− 0.04
November "	7.18	0.93	4.05	− 0.36
December "	7.18	1.09	4.05	− 0.42
January, 1926	7.18	0.97	4.05	− 0.64
February "	7.25	1.09	4.00	− 0.14
March "	7.29	1.08	4.00	− 0.51
Means	7.18	1.03	4.12	− 0.15

Comparing the values in Table II with those for the Longport well, we find that the mean high water interval of 7.41 hour for the entire series at the Longport well is 0.23 hour greater than the corresponding interval for the Atlantic City Steel Pier. The high waters in the well occur, therefore, on an average 0.23 hour, or 14 minutes, later than at the Steel Pier. The low waters in the well occur on an average 0.20 hour, or 12 minutes, later than at the Steel Pier. The ratio of the range of tide in the well to that at the Steel Pier is 0.556, or a little more than one-half, and this ratio is fairly consistent from month to month as shown in Table III.

Table III—Ratio of Range in Longport Well to That at Atlantic City Steel Pier

Month	Ratio	Month	Ratio
April, 1925	0.54	October, 1925	0.56
May "	0.54	November "	0.56
June "	0.54	December "	0.56
July "	0.55	January, 1926	0.56
August "	0.56	February "	0.57
September "	0.56	March "	0.57

Although there seems to be a small progressive increase in the ratio from the beginning to the last month of record, there is no indication that the ratio is affected by the large seasonal fluctuations of the water surface in the well.

Not only are the ratios obtained by comparing the monthly averages nearly constant, but it has also been found that by comparing individual ranges from day to day the ratios will generally fall between 0.5 and 0.6 for both large and small tides.

The closeness with which the fluctuations in the well follow the tides in the open ocean is indicated in the illustration below for a period when the tide in the open ocean was very much disturbed by a strong northwest gale.

The Cause

In regard to the probable cause of the tides in the Longport well, any explanation based upon hydrostatic equilibrium is eliminated by the fact that the surface of the water in the well is many feet below the mean sea level of the open ocean and that the tide itself is apparently uninfluenced by the large seasonal fluctuations in that surface.

Neither can these tides be attributed solely to the astronomical tidal forces acting directly upon the waters of the well or upon the earth's crust in that region. The fact that various irregular oscillations in the ocean, caused by meteorological conditions, are reflected by corresponding fluctuations of smaller magnitude in this well, indicates clearly that the rise and fall of the tide in the well is the direct result of the rise and fall of the tide in the near-by ocean.

The manner through which this action takes place is best explained by Mr. A. C. Veatch in his discussion of tidal wells in Long Island, New York.[2] This explanation assumes a plastic deformation of the strata of clay overlying the water-bearing area about the well.

The geological formations through which the Longport well passes are in general alternating beds of sand and clay to a depth of 374 feet, then solid clay or sandy clay to a depth of 720 feet, and then the water-bearing sand to a depth of 803 feet. As the load of the water in the open ocean is shifted by the rise and fall of the tides, a bending of the several strata of sand and clay, resulting from the varying pressure, causes a certain amount of water to be alternately forced into the well and drawn out again. As the area of the well opening is very small compared with the water-bearing area, a very slight deformation in the strata would be sufficient to account for the entire tidal oscillation in the well.

[2] Fluctuations of the Water Level in Wells, with Special Reference to Long Island, New York, *U. S. Geol. Survey Water Supply and Irrigation Paper No. 155*, Washington, 1906.

AMERICAN GEOGRAPHICAL SOCIETY

Meetings of March and April and Elections to Fellowship. Regular monthly meetings of the Society were held on March 23 and April 20 respectively at the Engineering Societies' Building, 29 West Thirty-ninth Street. At the March meeting Professor David M. Robinson of Johns Hopkins University spoke on "Explorations and Excavations in Asia Minor." Professor Robinson was acting director of the American School of Classical Studies in Athens, 1909–1910, and has made many journeys in Asia Minor. He showed slides of cultural sites, including Sardis, Ephesus, Pergamum, and Antioch, and described the scenery of the regions as well as the excavations and the reconstructions of the ancient monuments. At the April meeting, Colonel Theodore Roosevelt and Mr. Kermit Roosevelt described their "Explorations in Central Asia," and at the close, Mr. Suydam Cutting, photographer of the expedition, showed a series of moving pictures. The lecture was given to one of the largest audiences in the history of the Society. Mr. Kermit Roosevelt described the region traversed by the expedition, its scenery and people, and Colonel Roosevelt spoke particularly of the hunting of the rare Ovis Poli.

At the March meeting, President Finley presiding, and the April meeting, Honorary President Greenough presiding, there were presented with the approval of the Council the names of 84 candidates who were duly elected as Fellows of the Society.

Presentation of the Charles P. Daly Medal to Brigadier-General David L. Brainard and the Cullum Geographical Medal to Dr. Harvey C. Hayes. The presentation of the Charles P. Daly Medal to Brigadier-General David L. Brainard and of the Cullum Geographical Medal to Dr. Harvey C. Hayes (see *Geogr. Rev.*, Vol. 16, 1926, p. 134) took place in Washington on April 15 at a meeting of the Washington Academy of Sciences in conjunction with the Philosophical Society of Washington and the Biological Society of Washington.

Dr. George K. Burgess, President of the Academy, opened the proceedings by an appreciative reference to the opportunity of acting for the American Geographical Society in thus honoring two residents of Washington. He then called upon General Saltzman, Chief Signal Officer of the Army, to make the presentation to General Brainard on behalf of the Secretary of War. General Saltzman stated that he found this ceremony a "pleasing privilege," not only for the exceptional services rendered by General Brainard but for the affection and esteem in which he had long been held by his colleagues. "Bravery, courage, and generosity" distinguished his services on the Lady Franklin Bay Expedition of 1881–1884, an expedition whose geographical exploits included the gaining of the farthest north of the time and the wresting from England of a record held for three centuries. "A medal in itself is a trivial thing," said General Saltzman. "A medal which is a token of achievement becomes valuable. But a medal which is the recognition of mankind not only for unusual achievement, but for heroism and self-sacrifice, becomes a precious jewel and, General Brainard, it is a great honor for me to present you such a medal."

In acknowledging the award General Brainard paid tribute to General Greely: "Among all the officers I have ever known, I have never known one so brave and true as General Greely. The record of the expedition will bear me out on that." General Greely, called upon for a few words, said "I am not going to recount General Brainard's remarkable services in the field. I have this to say of him. He is a man. He is a man among men. He set an example as regards sense of duty, loyalty to the nation, and self-sacrifice in the interest of his fellow companions at that time."

President Burgess then called on Captain Walter S. Crosley to present the Cullum Medal to Dr. Hayes. Captain Crosley referred to the value of the results obtained from the sonic depth finders for "navigators and scientists, especially those interested in earth movements" and concluded with remarking that Dr. Hayes' connection with the Navy was a matter of considerable pride.

In accepting the medal Dr. Hayes made a modest disclaimer of his own work and referred to the importance of coöperative effort in scientific research. "I do not hesitate to receive this medal and the honors that go with it if you will believe that in doing so I honestly apportion those honors to the many men who have worked on the problem of depth finders. Nearly every one of them, if they had been backed by the Navy, would have solved it. And in particular I wish to divide the honors with the men who have worked with me in solving this problem."

Presentation of the Cullum Geographical Medal to Dr. Pedro C. Sanchez. The presentation of the Cullum Geographical Medal to Dr. Pedro C. Sanchez (see *Geogr. Rev.*, Vol. 16, 1926, p. 134) took place in Mexico City on April 12, 1926. The ceremony was performed by Ambassador Sheffield, who spoke as follows:

"By direction of my Government and on behalf of the American Geographical Society, I have the privilege and the honor of presenting the Cullum Geographical Medal awarded to you, Dr. Sanchez, in recognition of your distinction as scholar and scientist.

"The American Geographical Society is the oldest of its kind in the western world and its main object is the advancement of geographical science. The Cullum Geographical Medal has been annually awarded since 1896.

"For the year 1925 the Society awards the medal to you in commemoration of your contributions to geographical science. For many years you have made explorations and published maps of your own wonderful country which have added immensely to the scientific knowledge of the world. But beyond the compliment to you personally is the added value that such a medal has in the world of scholarship. There are no national boundary lines to culture, no racial barriers to scholarship, no political differences in intellectual life. These things are the precious possessions of all peoples, and this medal from a society in the United States to a scholar in Mexico stands as evidence of friendship and mutual recognition of the binding obligations of the cultural life upon our two nations.

"In the achievements of science and the highest ideals of scholarship may be found means to a better understanding and friendlier relations between our peoples. In that spirit and in recognition of your work, I deem it a special honor in the name of the American Geographical Society to present you with the Cullum Medal."

Dr. Sanchez in reply said: "To one who has devoted all his life to the study of science, it is a great satisfaction to be judged and stimulated by cultured men, especially by those who grouped in scientific societies follow with enthusiasm human progress in all its aspects.

"It is the cause of a great satisfaction to me that the noted Geographical Society of New York should have taken into consideration my work, and its verdict gratifies me immensely, since by honoring me it does justice to my country that never has and never will spare any effort to maintain its place with all dignity and decorum as becomes a civilized and cultured nation.

"I am greatly obliged to Your Excellency, Ambassador from the most powerful nation in the world, for presenting me with the reward bestowed upon my modest work by the Geographical Society of New York and beg you to express my deep gratitude to the aforenamed Society, as well as my sincere wishes that the scientific world may find in this institution a beacon that sends forth to the world the stimulus for work and lights the path leading to true knowledge."

GEOGRAPHICAL RECORD

NORTH AMERICA

Persistence of Plants in Unglaciated Areas of Boreal America. It has been generally held that in northern North America, during the Quaternary glaciations, all plants and animals were driven southward by the growing ice and returned as the ice sheets waned; but this view has to be considerably modified after Professor Fernald's studies. The results of his most recent researches are given under the above title in a memoir of the American Academy of Arts and Sciences (Vol. 15, 1925, pp. 237–342).

On the Shickshock Mountains of the Gaspé Peninsula and on the Long Range of western Newfoundland there are, mingling with arctic-alpine forms, hundreds of species of plants for the most part otherwise known only in the Rocky Mountains, the Cascades, the Sierra Nevada, the Coast Ranges, or in some cases in Alaska or on the Altai in Siberia. In the Magdalen Islands, in the Gulf of St. Lawrence, a few of these western plants also occur; and on the Torngat Mountains of northeastern Labrador several of them are to be found. Extensive exploration has failed to discover them at other places in the eastern parts of the continent. For various reasons their occurence and isolation in the region of the Gulf of the St. Lawrence cannot be explained by any kind of dispersal from the west in postglacial time.

The Shickshocks, the Long Range, the Magdalen Islands, and the Torngats are from the floristic point of view also remarkable because of their very large proportion of strictly endemic species, all of which are related to the western plants. These areas stand in sharp contrast to western Nova Scotia, which has an isolated coastal-plain flora of nearly two hundred species, immigrated there since the peninsula became free from the last ice sheet, with only a single endemic species. The western flora on the Gulf of the St. Lawrence must be vastly older. Now, it is significant that the last Quaternary ice sheet, and probably the last two, did not cover the Shickshocks, the Long Range, and the highest parts of the Magdalen Islands and of the Torngats, i. e. the very regions where the western plants and their endemic allies occur. Amazingly enough the plants under discussion have during postglacial time practically failed to migrate into the adjacent areas that were ice-covered—a further evidence of their antiquity. The younger floras that have invaded the glaciated areas after the uncovering show no such restriction. Thus it seems that the distinctive plants of the regions mentioned (Gaspé, the Magdalen Islands, western Newfoundland, and the Torngat Mountains) there outlived the last two glacial epochs and that their absence from the regions which were denuded by the Labrador and the Newfoundland ice sheets is due in the first place to their extinction from these areas; in the second, to the fact that they are so ancient and conservative that they have failed to occupy the recently available lands lying between their now isolated refuges. Also the high-arctic plants which have southern outliers in the unglaciated areas about the Gulf of St. Lawrence may have lived there since the middle Quaternary. The fact that the same arctic plants occur in the Torngat Mountains but not elsewhere in Labrador, that they are generally distributed over the Arctic Archipelago, and that they often follow the Cordillera to Alberta or Colorado or are known in the Northwest only in Alaska suggests that they also survived in the Arctic Archipelago, part of which may have remained ice-free during the last glacial epochs. The plants may have survived in spite of the fact that the ice sheets had much greater extent than assumed and reached from the Atlantic to the Pacific; for an eastward migration of the ice centers, as advocated by J. B. Tyrrell,

may not have taken place. Persistence of plants in the Arctic Archipelago through the last glaciations would in itself be quite natural.

The memoir treats many important problems not touched upon here. It is a standard work of unusually wide botanical, geological, and geographical bearing.

ERNST ANTEVS

The Dominant Position of Canada in the Wheat Trade of the World. As a wheat producer Canada holds third place, being outranked by the United States and Russia. She supplies about ten per cent of the world's wheat crop. Her high position in wheat production results from a rapid development of wheat culture on the prairies of Manitoba, Saskatchewan, and Alberta chiefly since the beginning of the twentieth century. These provinces produce 95 per cent of Canada's wheat crop and almost all of her export wheat (Canada as a Producer and Exporter of Wheat, *Wheat Studies of the Food Research Inst.*, Vol. 1, 1925, pp. 217–286, Stanford University, California).

The rise of Canada to a dominant position in the wheat trade of the world has come entirely within the last thirty years; she has attained the leading rank only within the last ten. Before 1897–1898 her exports did not materially exceed 10 million bushels a year, a negligible factor in the world's wheat trade. During the five pre-war years they averaged about 100 million bushels. In the past five years her yearly exports have averaged 230 million bushels, 32 per cent of all wheat entering international trade. Owing to the downward trend of wheat production in the United States and Russia since the war the increase of Canada's production has been the leading factor in maintaining supplies of wheat for export at a high level (J. A. LeClerc; International Trade in Wheat and Wheat Flour, *U. S. Dept. of Commerce, Trade Promotion Ser. No. 10*, Washington, 1925).

Expansion of Canadian wheat production has been promoted by the popularity of the wheat in foreign markets. It is hard and of high protein content. It gives a strong white flour which absorbs moisture freely, forms a strong elastic dough, and yields more loaves of bread to the barrel than weaker flours. Since the bulk of western European wheat is soft and much of the wheat exported from the United States, Argentina, and Australia is either soft or semihard, Canadian wheat flour is widely in demand for blending with weaker flours.

Canada's future as a wheat producer and exporter is somewhat problematical. Many factors enter in to modify forecasts. At the present time more than 20 million acres in the prairie provinces are sown every year, and another 10 million acres of fallow land are cultivated every summer to be sown to wheat the following spring. This area represents less than one-half of the potential wheat area according to the most recent authentic estimate of the wheat-producing possibilities of Canada (O. E. Baker: The Potential Supply of Wheat, *Econ. Geography*, Vol. 1, 1925, pp. 15–52). Dr. Baker estimates the potential wheat area of Canada as 80 million acres, yielding an average of 17 bushels to the acre—a potential crop of 1360 million bushels. Such estimates have a direct relation to the factors limiting the growth of population, but they afford little basis for forecasts concerning the developments during the next few years. An increased wheat production in western Canada will be stimulated by railway and government policies, by the expansion of population through natural increase in immigration, and by the availability of capital. It may also be stimulated by prices even lower than those which prevailed in 1924–1925. Any increase will be influenced by the return of Russia as an important competitor in the world's markets, which seems almost assured by recent reports of conditions in Russia and by the fact that the new lands available for wheat culture in Canada are less favorable than those now devoted to it. Diversified farming probably will develop and maintain high yields at the expense of larger acreage. Canada's crop and exports will continue to fluctuate greatly from year to year. While they may increase during

the next few years, it is doubtful if her average exports will register a momentous increase. However, even without a marked development Canada will continue to be a strong factor in the world wheat trade.

CLARENCE F. JONES

Transhumance in Nevada. Transhumance, or seasonal migration in grazing stock, is widely practiced in the semiarid portion of the United States where conditions of temperature, water, and feed render it necessary and large areas of public land make it possible. Transhumance in Nevada as illustrated on the accompanying map is discussed in a multigraphed paper "Agricultural Utility of Unreserved Public Domain in Nevada," released by the Department of the Interior, April 16, 1926.

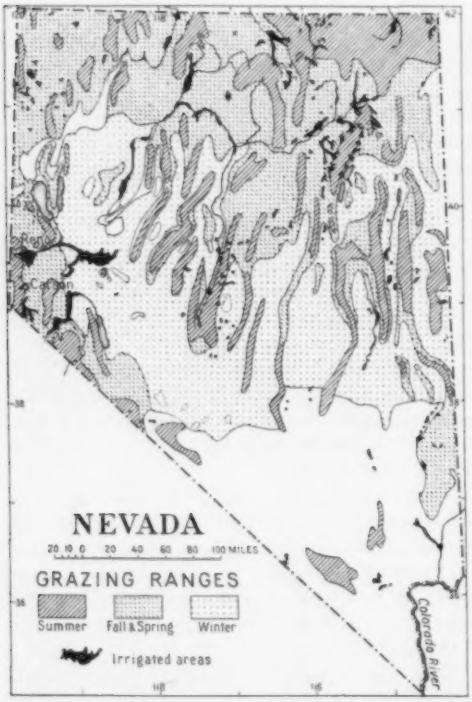

FIG. 1—Map showing pastoral use of the land in Nevada. Redrawn from map accompanying the Department of the Interior's report.

In June the sheep, of which there were over 1,100,000 in the state in 1925, are driven into the higher regions which provide feed, coolness, and a reasonably adequate water supply during the summer months. As autumn approaches and the weather becomes colder, the sheep descend into the foothills and higher valleys which constitute their fall range. Here the woodland gives way to sagebrush, and the water supply is insufficient for a long stay. The migration from the mountains to the higher valleys is of an altitudinal nature; but with advent of the winter months another element, that of latitude, appears. Whereas the summer range lies in general between latitude 39° and 42° N., the winter range is largely confined to the region between latitude 37° and 40° N. During the winter the sheep are consequently driven southward and pastured in the lower valleys, which, untenable in the summer because of heat and drought, form a suitable range in the winter when the lack of moisture is offset by snowfall.

Transhumance is also practiced in grazing cattle. The summer range is occupied in conjunction with the sheep, but the winter is spent on the irrigated areas. Much of Nevada's irrigated land is best suited to the cultivation of different types of fodder which can be profitably used for fattening the local live stock during the winter. Elko County, for example, contains one-third of the stock and one-third of the irrigated land of the state.

The summer range, which is about half the size of the other ranges and which must be shared with the cattle, limits the number of sheep that can be raised in Nevada but has made it possible for large flocks of sheep from adjoining states to be wintered in the state. The number of cattle is limited by the size of the winter accommodations or of the irrigated area.

Agricultural Geography of the Salt Lake Oasis. The Salt Lake Oasis is of particular interest to the student of agricultural geography. This oasis was developed under the distinctive control of the Mormon Church, whereas all other settlements in the region were primarily established for mining purposes. Here, for the first time in America, irrigation was utilized on a large scale by Anglo-Saxons. Furthermore, this is now the area of the most successful dry-farming practices. The persistence of the original Mormon methods of colonization and irrigation has led to unexpected problems in this day of a highly concentrated population. The present system of irrigation ditches which is the result of numerous expansions does not permit of the highest efficiency. Following the original plan, the farmers continue to live in town. While this leads to a strong community life, much time is lost in going back and forth to the farm, and the absence of a permanent residence on the land precludes the raising of much live stock. The small size of the farms renders only the most intensive type of farming profitable. On the irrigated lands alfalfa is the principal crop, and sugar beets are the cash crop. Fruit is the most important crop on the irrigated bench lands, and wheat in the dry-farming area. A nice adjustment between live stock and farming is made by giving a final fattening on the farms to the cattle that have been grazed on the desert or in the national forests.

The distance of the oasis from large markets has meant that, unless the agricultural products are utilized locally, it is almost imperative to manufacture them into some form that can bear the heavy freight charges of the long haul. Hence sugar, canned fruits and vegetables, flour, meat, and dairy products have become the agricultural exports rather than the bulky primary products. Mr. Charles Langdon White has discussed the subject in detail (The Agricultural Geography of the Salt Lake Oasis: *Denison Univ. Bull., Journ. of the Scientific Laboratories*, Vol. 21, 1925, pp. 117–283).

National Parks in the Eastern United States. The desirability of creating additional National Parks in the eastern United States—where that on Mount Desert Island has been the sole representative—led the Secretary of the Interior to appoint a committee of park experts for examination of possibilities. After an eight months' survey of the southern Appalachian Mountains the committee recommended two areas—that of the Blue Ridge in Virginia and that of the Great Smoky Mountains in North Carolina and Tennessee. It was felt that these two regions best embodied such distinctive characteristics of the Appalachian Mountains as the steep-sided ridge and valley topography, the lack of bare crags and cliffs, the generally heavy covering of vegetation, and the numerous streams.

The Blue Ridge of Virginia, to be called the Shenandoah National Park, is distinguished by a high continuous ridge giving remarkable views over the Piedmont on one side and, on the other, of the Shenandoah Valley. The Great Smoky Mountains, so called because their tops are often covered with clouds, as part of the Unaka Mountains, form the southern climax of the Appalachian system. There are eighteen peaks of over 6000 feet in elevation in the park (proposed size of about 700,000 acres). Half of this is covered with virgin timber, and the whole area is considered one of the richest collecting grounds in the United States. Illustrations and a map showing the proposed boundaries and the Cherokee Indian Reservation which will be included within the area are to be found in the *National Parks Bulletin* (No. 46, November, 1925).

A third park including the well known subterranean wonders of Mammoth Cave has also been proposed during the present year. In accordance with the usual custom the land for these National Parks must be presented to the Government which will then undertake their administration. Local organizations have already succeeded in raising sufficient funds for the purchase of the land to prove their good faith, and Congress has recently enacted legislation authorizing the creation of the Shenandoah, the Great Smoky, and the Mammoth Cave National Parks.

Karst Topography and Cavern Capture in Kentucky. Several U. S. topographic sheets of the karst country of Kentucky are now available, and some of them have been described (W. R. Jillson: American Karst Country, *Pan-American Geologist*, Vol. 42, 1924, pp. 37–44). The following note concerns the Cub Run quadrangle (1925) in west-central Kentucky just north of the Mammoth Cave. The area represented is a submaturely to maturely dissected portion of the Appalachian Plateau. Sink-hole development is marked, some of the numerous depressions attaining a diameter of more than half a mile and a depth of eighty or one hundred feet. Big Sink, near the eastern edge of the quadrangle, is one of several showing five depression contours, while a few miles farther south an irregular branching sink seems to be part of a normal valley system which has lost its stream by underground drainage.

FIG. 1—Block diagram of karst phenomena from the Cub Run quadrangle of west-central Kentucky.

A beautiful example of "cavern capture" appears to be represented near Lone Oak Church, northeast of the center of the quadrangle (Fig. 1). West of the little hamlet just mentioned, two streams take their rise and flow eastward a mile or two before uniting, at which point they disappear underground. The valley continues to the northeastward at a distinctly higher level and evidently deserves its name of Dry Run. It seems clear that the two tributaries rising west of Lone Oak Church were formerly the headwaters of Dry Run. Subterranean capture beheaded this stream, and, as the captured drainage still escapes beneath the surface, the map does not clearly indicate its present course. Suspicion points to the next stream south, Spike Laurel Run, as the captor, for its bed is considerably lower than that of Dry Run at no great distance across the divide from the point of capture. Since the capture both beheaded tributaries of Dry Run have behaved like normal captured streams, deeply entrenching themselves in narrow gorges. The only difference is that in the present case the diverted waters escape underground, and the gorges due to capture therefore form irregular sink holes approximately a mile long.

The Cub Run quadrangle also affords a beautiful example of entrenched meanders in the Nolin River, which traverses the area from northeast to southwest in a gorge remarkable for the complexity of its serpentine course. (Note prepared in connection with a course on Map Interpretation at Columbia University.)

HENRY S. SHARP

The Drowned Meanders and Flood-Plain Scrolls of Reelfoot Lake, Northwestern Tennessee. The Reelfoot Lake sheet of the U. S. topographic map (1925) has a special interest in that it shows part of the region affected by the New Madrid earthquake of 1811, when large areas of land subsided, new lakes were formed, unusual legal complications were caused, and earthquake phenomena of various kinds developed (M. L. Fuller: The New Madrid Earthquake, *U. S. Geol. Survey Bull. 494*, 1912). Reelfoot Lake itself was formed as a result of this famous earthquake and shows certain peculiarities which have been attributed to local crustal disturbances initiated by the shock.

To observe the latter features to best advantage one must secure the edition of the map showing woodland by green overprint. It will then appear that in the Grassy Bend section of Reelfoot Lake (Fig. 1) there are series of concentric, curved strips of woodland, concave toward the northeast, growing in the shallow water of

the lake. The partially submerged wooded strips are conformable in orientation and pattern with curved strips of flood plain extending into the lake from the southwest side of a low wooded peninsula (known locally as Horse Island) projecting into the lake from the northwest. There can be no doubt that all these strips represent a succession of faint ridges or mounds in the flood-plain deposits, partly visible above water but for the most part so far submerged that their positions are indicated only by the belts of cypress trees rising out of the water from their crests. Two excellent airplane photographs of the ridges can be seen in a recent article by Wilbur A. Nelson (Reelfoot—An Earthquake Lake, *National Geogr. Mag.*, Vol. 45, 1924, pp. 95–114), who interprets them as remnants of ridges set up in the loose flood-plain alluvium by the earthquake waves of 1811.

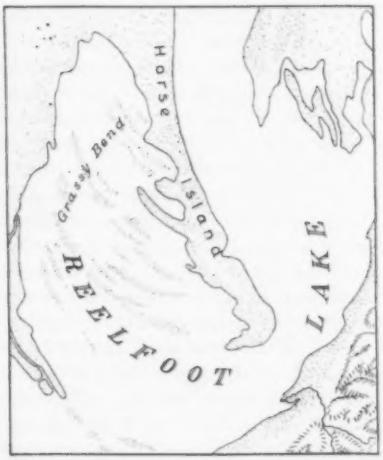

FIG. 1—Diagrammatic sketch of a portion of Reelfoot Lake (scale slightly over 2 miles to the inch) showing the partially submerged belts of cypress trees.

Reelfoot Lake evidently represents the drowned meanders of a former river course, and the size of the meanders is obviously appropriate to a former course of the Mississippi. The concentric wooded ridges are now seen to be identical in pattern and position with the crescentic sand bars of "flood-plain scrolls" normally deposited on the inner side of a migrating meander. The upstream ends of the ridges are sharply truncated along the northeast shore of Horse Island in precisely the same manner that flood-plain scrolls are normally truncated at their upper ends by the down-valley migration of the meander as a whole. The phenomena of the concentric ridges can be duplicated at countless points along the Mississippi, both within and without the earthquake area, and there seems no doubt that the features observed in Reelfoot Lake represent normal flood-plain scrolls developed by a former meander of the river. The earthquake did not cause the ridges, but the movement associated with it brought about their partial submergence. (Note prepared in connection with a course on Map Interpretation at Columbia University.)

HENRY S. SHARP

SOUTH AMERICA

Rubber Production in the Amazon Valley. Can the Amazon Valley recapture an important place in the world's production of rubber? This is the theme of the Crude Rubber Survey's report "Rubber Production in the Amazon Valley" (by William L. Schurz, O. D. Hargis, C. F. Marbut, and C. B. Manifold, *U. S. Dept. of Commerce, Trade Promotion Ser. No. 23*, 1925).

We may first recall that over nine-tenths of the world's rubber comes from plantations of the Middle East (The Plantation Rubber Industry in the Middle East, *U. S. Dept. of Commerce, Trade Promotion Ser. No. 2*, 1925, reviewed in the *Geogr. Rev.* Vol. 16, 1926, pp. 162–164). In the Amazon, the home of the chief rubber-producing species, the industry remains in a primitive condition: what are the prospects of its production of wild rubber? And can plantation rubber be introduced? The study is essentially comparative. Contrasts between conditions in the West and East are profound, and quantitative comparison is difficult. It is not possible, for instance, to determine the average yield per acre or for trees of given age in Amazonia as in the East. However, from what is known of yields estimated by *estradas*, or groups of

wild trees averaging 150 in number, the Commission arrived at the conclusion that under an equality of circumstances individual tree yields would be greater in the Amazon. On the other hand, the common South American belief that the Amazon latex is inherently superior appears to be unfounded.

Again, costs of production are hardly comparable. In the Amazon there are no wages, there is no fixed overhead, and capital expenditure are usually small. Production per man per season varies greatly according to region. In the lower Amazon, long worked over, it can be averaged at 450 pounds whereas on the upper waters of the southern tributaries it ranges from 800 to 2200 pounds. Taking the expenditure on supplies for the *seringueiro* and dividing this by his production gives perhaps the best idea of cost. Though conditions have improved in recent years, the industry remains on an uneconomic basis. Trade is still unduly complicated in spite of the decline in the *aviador* system of intermediaries between the *patrão*, the producer, and the trading houses in Manáos and Pará. One of the most important factors of the industry is the exchange of merchandise for rubber, the profits on the former being larger than from the latter. Indeed, over vast areas the industry is sustained only by the profits from this source. But in this system also an improvement is to be noted in the encouragement given to the *seringueiro* to provide his own foodstuffs as is notably done in the Acre territory.

Any considerable increase in the wild rubber production of Amazonia must come from extended utilization of the Castilla tree—a secondary and comparatively wasteful source, for the tree is not tapped but cut down—or from the exploitation of virgin fields. Large areas north of the Negro and west of the Branco have not been explored for rubber, and there are great areas unexplored on the uplands of northern Matto Grosso and in southern Amazonas and Pará, where the little that is known points to "the existence of an enormous number of rubber trees which have not yet been exploited." A member of the Brazilian commission accompanying the American party reported the existence, between the Gy-Parana and the Roosevelt, of natural prairies with forest clumps consisting of almost pure stands of *Hevea brasiliensis*.

Some extravagant estimates have been made of the potential production of wild rubber from the Amazon. At the time of the great boom, 1910–1912, the annual export was over 45,000 metric tons. Given a sufficiently high price this figure might be reached again, but to double or possibly treble it would call for a combination of unusual prices and conditions.

Now what are the possibilities for plantation production? The Hevea requires deep, friable, and well drained soil, "at least one in which the ground water level lies, for a considerable part of the year, at a depth of several feet"; that is the uplands are preferable to the alluvial lands, the periodically inundated *varzea* (compare C. F. Marbut and C. B. Manifold's paper on soils of the Amazon Basin, pp. 414–442 of this *Review*). Regions naturally bearing great numbers of Hevea trees are the uplands drained by the Beni, Abuná, Acre, Upper Juruá, Upper Purús, and parts of the southern tributaries of the Madeira and the lower Amazon. As regards drainage and soil conservation the problems here presented are not so great as in the East. Temperature conditions are similar, with some advantage to the Amazon. The total rainfall, however, is less than that of the best rubber regions of the East and is not so well distributed. Meteorological stations are few in number, but it is well established that the middle portion of the basin is much less rainy than the eastern seaboard or the Andean borders. A period of three months without rain is not unknown. Pará, for instance, has 252 rainy days, Parintíns 134. The northern half also is drier than the southern. Boa Vista on the Rio Branco has only 55 inches of rain and 113 rainy days. The rainfall too is erratic. Fifteen years' observations at Porto Velho show a range from 49 inches (1914) to 153 inches (1920). In the drier regions it takes longer for the trees to reach the tapping age; otherwise there seems no reason why the planted Hevea should not be comparable with that of the East. Moreover, the

Amazon Valley possesses one great advantage in that seed can be obtained from known high yielders.

There are few known data on which to base an estimate of the cost of establishing and running plantations in Amazonia. As regards labor the situation is less favorable than in the East (see W. L. Schurz: The Distribution of Population in the Amazon Valley, *Geogr. Rev.* Vol. 15, 1925, pp. 206–225). The commission estimated that the region itself could assemble a labor force of 30,000 men, sufficient to care for 150,000 acres and probably "as good as any body of tropical workmen." Additional men might be drawn from the favorite recruiting ground of the semiarid northeastern states. It would be easiest to secure labor for Pará. Conditions of land tenure vary from region to region. Little public land is available in the Acre territory and Amazonian Bolivia. In some parts of Brazil provision is made for free grants. Land taxes are much lower than in the East, export taxes on Brazilian rubber are higher. The far interior, where excellent physical circumstances prevail, presents greater transportation problems.

Enough has been said to illustrate the comprehensive nature of the Rubber Survey's report. It covers a good deal of the geography of Amazonia. Rubber was the great factor in the opening up of this country. It is still the prime industry of the upper reaches of the southern tributaries. And the basin as a whole is still in the primitive extractive stage of industry. "The foreigner in the Amazon Valley is strongly impressed by the small development of agriculture in relation to the manifest fertility of the soil and the opportunities which the industry would appear to offer" (p. 205). Speaking of Manáos the report says again, "Considering the fact that this part of the country has been settled for centuries the lack of industrial and agricultural development is nothing short of astounding. Nowhere in the whole region does there exist what could be called a farm or a plantation from the American viewpoint" (p. 227).

A Survey of Peruvian Commerce. Peru ranks fourth among the countries of South America in respect to the total volume of its foreign trade, being surpassed by Argentina, Brazil, and Chile. A useful survey of the recent development of this trade is given in W. E. Dunn's "Peru: A Commercial and Industrial Handbook" (*U. S. Dept. of Commerce, Trade Promotion Ser. No. 25*, Washington, 1925)—the most complete and accurate compendium of the economic geography of Peru yet published.

Previous to the great catastrophe in Peruvian history—the disastrous war with Chile (1879–1884)—the volume of the Republic's foreign commerce was considerably greater than during the quarter century following. In 1877 the foreign trade amounted to 48 million dollars as a result of the exports of guano and nitrate. It did not again reach this figure until 1905. Both imports and exports have shown a notable and steady growth during the last two decades: the trade increased to 157 million dollars in 1923 and, according to the Statistical Abstract of Peru for 1924 (Bureau of Statistics, Lima, 1925) to 210 million dollars in 1924. Yet in proportion to its area and resources the trade of Peru is not large.

Commercial developments are handicapped by the ethnic character of the population and by the difficulties of transportation within the country. Indians and Mestizos constitute fully 85 per cent of the population. The Indians purchase few imported goods and produce little that enters the export market, except as they work on the sugar and cotton estates, in the mines, or tend the flocks of the extensive *estancias* of the plateau. Their wages are low, and their buying power is small. Most of the mestizo population also has low purchasing power and relatively small producing capacity.

Although Peru was the pioneer country of South America in railway construction, its first line having been opened to traffic in 1851, it now ranks fifth in mileage; in

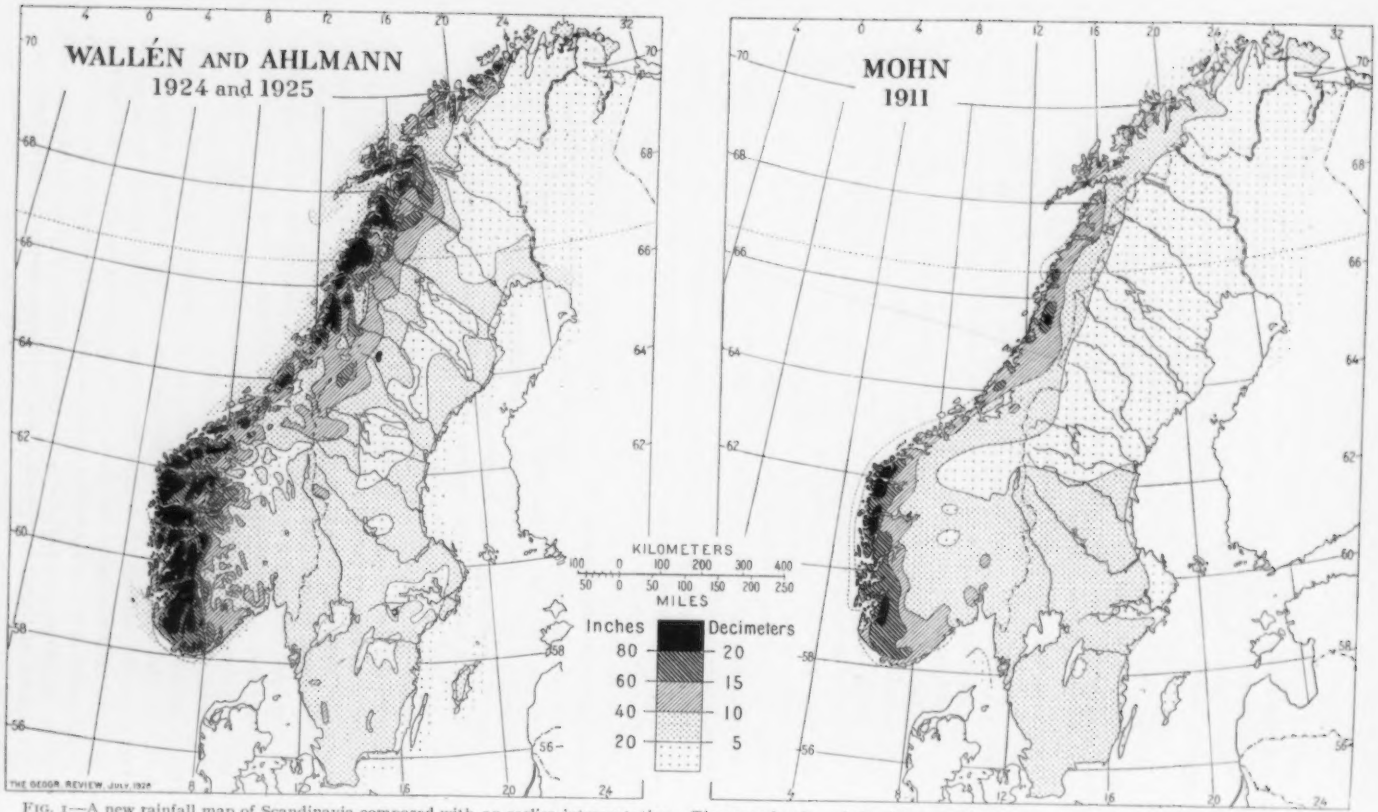

FIG. 1—A new rainfall map of Scandinavia compared with an earlier interpretation. The reproduction of the Ahlmann-Wallén map, scale approximately 1:17,000,000, is generalized from the original on the scale of 1:2,500,000. The Mohn map appears in "Nedbör i Norge," *Naturen*, March–April, 1911, and in Haffner og Werenskiold: Norges Geografi, Christiania, 1912.

1924 2018 miles of steam road were in operation. Yet the republic has no railway net; most of the railways consist of short isolated lines of varying gauges connecting an ocean port with the chief towns and plantations of the adjacent fertile irrigated valleys. Only two systems—the Central and the Southern—extend from the coast into the elevated Andean region. Most of the Andean and montaña regions, which include all of Peru except the narrow strip of coastal desert, still depends upon the primitive means of river and pack-animal transportation.

Ocean transportation is of particular importance to Peru, not only from the standpoint of international communication, but also as a means of travel between various isolated valleys of the coastal zone. No longitudinal railway connects the irrigated lands, and the sandy stretches between the fertile valleys make travel so difficult as a rule that it is far easier to utilize the ocean highway even for short distances.

Peru has a variety of raw products for the world's markets, in contrast to Chile or Bolivia which depend almost entirely upon the products of the mine for export commodities or Argentina and Uruguay which ship only foodstuffs and raw industrial materials of the farms and the ranges. Yet of the country's annual exports of approximately 100 million dollars, four items make up almost 90 per cent of the total (three year average, 1921–1923): sugar 26 per cent, cotton 23 per cent, petroleum 20 per cent, and copper with some silver included 19 per cent. Thus in a country so long known for its minerals one half the exports consist of products of the farm. The shipments of cotton increased from 22 million pounds in 1905 to 95 million pounds in 1924; those of sugar from 300 to 600 million pounds in the same period.

The surplus of agricultural products is definitely limited, for the yield of these major crops cannot be increased more than 20 per cent by better methods of cultivation, more efficient utilization of the water supply, or bringing new lands under irrigation. Also a larger production does not necessarily connote increased exports, for Peru is using more and more of her cotton crop for manufacturing.

Petroleum, the most important mineral product, has replaced copper and other minerals which held a leading position for three centuries. It comes almost entirely from the northern part of the coastal desert. While the bulk of the production is exported (76 per cent in 1923), that retained for domestic consumption is the more important owing to the general lack of fuel in the country. The petroleum exports increased from 279,000 barrels in 1903 to 4,943,000 barrels in 1924.

While the agricultural production of the coastal desert is definitely limited by the available water supply, and while the minerals of the highland zone are all exhaustible, the montaña country holds great agricultural, forest, and probably mineral resources as yet untouched. However, the extreme isolation of the region, the difficulties of providing adequate transportation facilities for outlets of goods, and the lack of population will relegate any considerable development of this virgin territory to a rather distant future. Without this region the steady increase in the export and import trade during the last two decades has paved the way for a healthy growth of the republic and a marked period of prosperity.

CLARENCE F. JONES

EUROPE

A Rainfall Map of the Scandinavian Peninsula. It has long been known that Norway shows a great difference between the precipitation indicated by rain gauges mostly near sea level and that computed from the run-off of the rivers. The rainfall on the plateau surfaces of western Norway is without doubt much greater than that caught in gauges in the deep fiords below. In 1904 the writer, starting from Loen in the Nordfjord, was turned aside by heavy rains from the ascent of Lodalskaupe no less than three times in as many weeks, while the weather was steadily clear and sunny on the upper waters of Sognefjord. As he learned later, the contrast is characteristic.

This greater rainfall on heights is familiar everywhere. Engineers have recourse to rain gauges to learn what supplies they may count on for reservoirs, and they rarely fail to be disappointed by such records. The gauges, generally placed at the dwellings on low ground, tell only the rainfall at that level. Meteorologists, however, have sometimes been slow to approve of attempts to go beyond the actual record of rain gauges in precipitation, yet gauges placed on the heights never fail to record great increase in rainfall there. The expense of maintaining mountain observatories has caused many of them to be abandoned—those on Mt. Washington and Ben Nevis, for example—but not before they had amply demonstrated the abundance of rain above. Mt. Washington, for the 17 years of its existence as a rainfall station, showed over 80 inches of precipitation in a region that catches about 40 in its low-level gauges. The expense of maintaining high stations is likely to keep them always few.

Norway would be a particularly hopeless country to fit out with gauges at all levels, the 96 per cent of the surface not available for human life being mainly uninhabited wastes far above sea level. We look eagerly for means of correcting the low-level record in accordance with that of the levels above. This has been done by H. W. Ahlmann in a recent map (Karta över den årliga nederbördens fördelning på Skandinaviska halvön, *Meddel. från Statens Meteorol.-hydrogr. Anstalt*, Vol. 3, No. 4, Stockholm, 1925) in which he extends Wallén's work on Sweden (Nederbördskartor över Sverige, *ibid.*, Vol. 2, No. 3, Stockholm, 1924) to cover the whole of the peninsula. In preparing this map Ahlmann has not only followed Wallén in using all the records of rain gauges known, together with the run-off of the rivers, but has used also for the loftier *fjell* of Norway a method of calculating annual rainfall from the occurrence of glaciers which he developed in 1924 and published with a map of precipitation in western and central Norway derived by its means (H. W. Ahlmann: Le niveau de glaciation comme fonction de l'acumulation d'humidité sous forme solide, *Geogr. Annaler*, Vol. 5, 1924).

Between gauges and stream run-off there are 537 stations used in Norway—unfortunately we are not told how many of each—and over a hundred more points are given by calculation from the glaciers. The evaporated part of the rainfall is allowed for in estimating precipitation from run-off by "using Wallén's curves for the forest rivers of Swedish Norrland for run-offs up to 500 millimeters [of equivalent rain], the curves for the Swedish high *fjell* for run-offs between 600 and 1100, while run-offs from 1100 to 1400 are increased by 400 millimeters, those from 1600 to 1900 by 350 millimeters, and those of over 2000 by 300 millimeters. The reason for diminishing the allowance for evaporation with increasing run-off is that the higher run-offs occur only in the high *fjell* country with low temperatures and mostly moist, cloudy air. In spite of the uncertainty that admittedly affects the values of evaporation, the errors can hardly amount to more than ten per cent of the total precipitation and cannot have any appreciable effect on the course of the isohyetal lines." The author takes considerable satisfaction in listing his 675 points of observation for Norway. As a matter of fact it is scant enough, one station to 184 square miles. The rain gauges in Switzerland are one for every 48 square miles, in the United Kingdom one for every 31.

Besides the measured and calculated precipitation data, Ahlmann made direct observations on the increase of rain with elevation through the summers of 1923 and 1924 in the Jotunheim district, where he set a series of gauges all within a distance of 10 kilometers, at elevations of 46, 625, 882, 1300, and 1600 meters. Observations were made from June 20 to August 31 in each of the two years. Up to 1000 meters there was an increase of precipitation of 70 millimeters for every 100 meters. Up to 1600 meters the increase was 80 to 90 millimeters: "The value of available precipitation which I calculated for a height of 1600 meters in that region was about 1500 millimeters. Taking the evaporation at 400, the annual precipitation would be

1900 millimeters. Calculation with my previously learned values of increase of precipitation with height and the precipitation observed at the base station Fortun from 1876 to 1915 gave a similar figure, 1970 millimeters. The measurements at valley gauges near are 800 to 1000 millimeters." If those valley records were used in drawing isohyetal maps they would give "a wholly inaccurate picture of the precipitation on that upland."

A number of the glacier stations comparable with western Jotunheim in position suggest 80 millimeters for each 100 meters as the increase of precipitation with height. Exposed positions on the west and north coasts have values up to 100 millimeters, like points in the rain shadow of the *fjell* to the eastward. Wallén found even greater values in the lee of the high Swedish *fjell*.

As a check the map for Norway was constructed quite independently of Wallén's map for Sweden, but the two came together at the national frontier very satisfactorily.

The resultant map follows the relief of Scandinavia much more closely than the older maps of precipitation. The greatest increase in the values of precipitation arrived at is, of course, at the western border of Norway, where amounts as high as 5500 millimeters are calculated; but the greatest change in the general pattern of isohyetal lines is northern Sweden. Almost half that country in the north was formerly represented as of scanty rainfall. Ahlmann-Wallén's map has sufficient (50 to 1000 millimeters) rain all over Sweden with gaps of scanty rainfall here and there throughout the whole kingdom.

MARK JEFFERSON

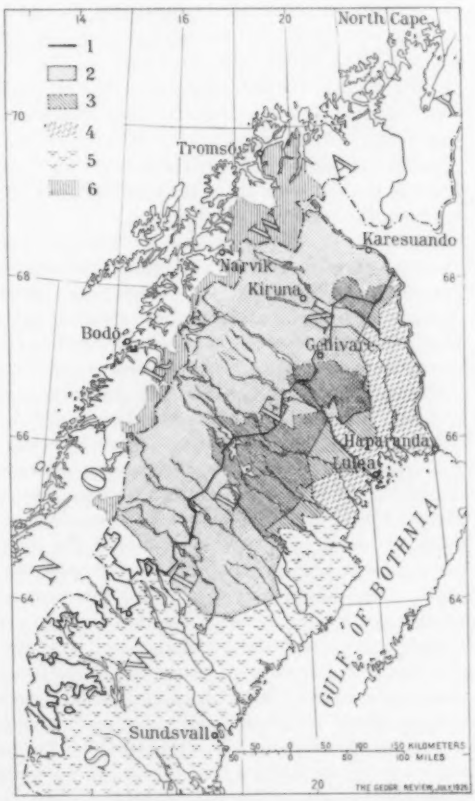

FIG. 1—Map illustrating present status of reindeer grazing in Sweden, scale approximately 1:10,000,000, generalized from Bergström's map. Key to legend: 1, Limit of agricultural settlement; 2, Lapp domain; 3, Area of woodland reindeer grazing; 4, Extension of woodland grazing under special circumstances; 5, Extension of mountain reindeer grazing under special circumstances; 6, Norwegian districts where Swedish Lapps have special grazing rights.

The Distribution of Reindeer Grazing in Sweden. Erik Bergström, superintendent of the nomadic schools for the Swedish Lapps, has prepared a map to show the present distribution of reindeer grazing in Sweden, especially intended for use in his schools (Karta över renskötselns utbredning i Sverige, scale 1:1,000,000, Stockholm, 1923). An accompanying typescript by Dr. K. B. Wiklund (see his paper "The Lapps in Sweden," *Geogr. Rev.*, Vol. 13, 1923, pp. 223–242) provides a brief description of this detailed and careful work.

The surprisingly wide distribution of reindeer grazing in Sweden, down to about latitude 62° N., shows the industry is still important. In 1921 Sweden

had 161,577 reindeer valued at about five million Swedish crowns, or a little less than $1,500,000. This coexistence of two forms of civilization as different as reindeer nomadism on one hand and modern agriculture, forestry, and highly developed manufacturing on the other is a remarkable phenomenon. The Lapps, however, constitute as a rule only a small minority of the whole population. In 1920 Sweden had 8129 Lapps; 2775 of these were nomads occupying particularly the land above the limit for agricultural settlement which was drawn years ago for their protection. At that time 2355 of the Lapps were classified as Forest Lapps; the remainder are called Mountain Lapps. The Forest Lapps are in the main permanent settlers. They stay in the woodland, mostly distributed within the boundary of agricultural settlement, the year round and beside breeding reindeer occupy themselves with farming to some extent.

OLOF JONASSON

The Geography of Sardinia. "The forgotten island: thus rightly may Sardinia be called. No other land of Europe has been so completely severed from the main trends of European history or so completely shut off from the general development of culture and civilization as this island, where the Middle Ages ended only with the unification of Italy" (Alfred Steinitzer: Die vergessene Insel: Sardinien und die Sarden, Gotha, 1924). The effects of centuries of isolation show themselves in the survival of many distinctive customs and costumes; in the presistence of a local speech sufficiently different from Italian to be regarded as an independent Romance tongue; in primitive methods of agriculture and an elaborate vendetta code; and also, perhaps, in the short stature of the mountain folk and puny build of their draft and pack animals, the results of inbreeding.

Steinitzer in the attractive, semipopular, illustrated volume just quoted and E. Scheu (Sardinien: Landeskundliche Beiträge, *Mitt. Gesell. für Erdkunde zu Leipzig, 1919–1922*, Leipzig, 1923, pp. 32–102) have recently made it possible for students to gain an adequate conception of the geography of this neglected outlier of the Italian kingdom. Scheu's study in particular is admirable in the way in which it brings out the relations between physiography and human enterprise.

Physiographically Sardinia falls into two great divisions, east and west. The rocks of the eastern half of the island are mainly crystalline and metamorphic. Much of this area, having been reduced to base level and overlain by chalk-making deposits, was subsequently uplifted and dissected, apparently submaturely. Thus were produced extensive tracts of plateau, cut by deep V-shaped valleys. In some places the crystalline rocks rise above the general level of the chalk plateaus as genuine mountain masses. The western half of the island, on the other hand, is relatively lower, consisting largely of basaltic outflows to the north and Tertiary lowlands to the south. The Campidano plain which cuts across southwestern Sardinia from sea to sea lies in a graben not unlike that of the upper Rhine.

The facts of settlement and economic activity are closely related to these larger physiographic divisions as to the lesser subdivisions within them. The chalk plateaus and granitic mountains of the east are primarily pastoral, a wild land of sparse and backward population never altogether subjugated by the various early conquerors of the island. The west, on the other hand, with its fertile alluvial plains and tracts of weathered basalt (the latter constituting the finest wheat country), have always been more thickly settled. Sardinia's armor of isolation has been penetrated by external cultural influences—Punic, Roman, Saracen, Spanish, Pisan—from the west and south, not from the east. Western Sardinia, and especially the Campidano plain, was one of the granaries of the Roman Empire, and it is from the west that most may be hoped for in the future regeneration of the island's prosperity.

As a whole Sardinia is thinly populated, having only 36 inhabitants per square kilometer as against 120 in Italy and 137 in Sicily. The most densely settled areas

are the Campidano plain, the mining region of Iglesiente in the extreme southwestern corner of the island, and the vicinity of Sassari in the northwest: these have 50–100 inhabitants per square kilometer. The remainder of the west has 25–50, and the east only 10–25 (compare Montana, 9.5; Colorado, 23.5). The population is on the increase, however, especially in the pastoral regions, where the flocks are growing and the areas given over to them are being enlarged at the expense of agricultural land. Except in the extreme north, the population, as in Sicily, is concentrated in villages of considerable size, as is shown by these figures:

85	settlements	have	between	500	and	1000	inhabitants
162	"	"	"	1000	"	3000	"
48	"	"	"	3000	"	5000	"
19	"	"	"	5000	"	10,000	"
6	"	"	over	10,000			"

Most of the agricultural land is in the hands of small proprietors, and approximately half the pastoral land in the mountains is held in common ownership. Except in the Campidano plain, there are few great estates, Sardinia in this respect being markedly different from Sicily (see *Geogr. Rev.*, Vol. 14, 1924, pp. 144–145).

Manufacturing in the modern sense of the term is almost non-existent, the only manufacturing industry which exports its products to any significant extent being that of cork in the northern part of the island. Sardinia has only 318 factories as compared with 1438 in Sicily. Plans for the industrial development of Sardinia in conjunction with the conservation of water and the improvement of agriculture are discussed elsewhere in this number of the *Review* (pp. 395–402).

AFRICA

Mapping and Exploration in the Egyptian Deserts. The remarkable progress made in the surveying of the Egyptian deserts is described by Dr. John Ball in the *Compte Rendu* of the International Geographical Congress held at Cairo in 1925 (Vol. 2, 1925, pp. 140–170). Today 91 per cent of the Sinai peninsula is topographically mapped on a triangulation basis, and 55 per cent of the Eastern Desert. Of the Western or Libyan Desert, however, only four per cent has been so mapped and 70 per cent remains unexplored. Regular survey began in 1905 after a wave of mining speculation that swept the country east of the Nile. Gold was the first attraction, then petroleum; in 1911 the mining of phospate rock began on the Red Sea coast, and in 1912 the commercial exploitation of manganese in west-central Sinai. Some surveys were made in response to military needs, and the coastal strip from the Nile delta was mapped for projected agricultural development. During the war the network was carried from the Nile to Palestine, and a chain was run from Cairo to Wadi Natrun. Since 1919 work includes a strip from the Nile to Baharia and Siwa. In all regions traversed topographical mapping is carried out simultaneously. Immense regions in the Western Desert, however, are not susceptible of regular survey, which is impracticable with camel transport for distances much more than 100 kilometers from a water supply. From the Arkenu and Owenat oases, for instance, it is over 400 kilometers to the nearest water and 830 kilometers to the nearest Egyptian well, Bir Terfawi.

In connection with the mapping of the Libyan Desert we may note the pending delimitation on the ground of the Egyptian-Cyrenaican boundary following the accord signed at Cairo on December 6, 1925. Text of the accord with map and accompanying documents has been published by the Egyptian Ministry of Foreign Affairs (La frontière occidentale de l'Egypte, l'accord italo-égyptien du 6 Décembre 1925, Cairo, 1926). The text is also available in *Renseignements Coloniaux* (*Suppl. à L'Afrique Française*), January, 1926, the map in *L'Afrique Française* for March. By terms of the treaty Sollum goes to Egypt with the wells of Ramla, which were put

in working order by the Italian Government, and the connecting strip of territory. Italy secures Jarabub, considered so important to her for strategic reasons.

The strategic character of this oasis is reflected by Hassanein Bey in his book "The Lost Oases" (New York and London, 1925). It was here that the founder of the Senussi established his headquarters, and it remains today a center of education and religion. "The Lost Oases" is the account, delightfully written and illustrated, of the author's journey in 1923 from Sollum to El Obeid, a distance of 2200 miles. The scientific results have already appeared in the *Geographical Journal* (see the note "Across the Libyan Desert Through Kufara," *Geogr. Rev.*, Vol. 15, 1925, pp. 141–142). It will be recalled that they include rectification of the position of Zieghen Wells and Kufara and the putting of the "lost oases" Arkenu and Owenat definitely on the map.

A rumor of the existence of an oasis "Owanat" had earlier reached Mr. W. J. Harding King while engaged in exploration in the Libyan Desert, and he had traveled 150 miles in that direction. The scientific results of his three years in the Desert (1909–1912) also have appeared in the *Geographical Journal*. In "Mysteries of the Libyan Desert" (London, 1925) he provides an entertaining and illuminating narrative. He made eight trips south and west of Dakhla, proving that the reported "impassable sea of enormous sand dunes" did not exist, and also explored the eastern and western sides of the great depression in which Farafra lies and an interesting area, "a network of small depressions," between Dakhla and Kharga. On the basis of native information collected orally and from the "books of treasure," he compiled a map of the desert, showing many names not previously recorded. Several of these have been subsequently verified as being in approximate position. It may be noted that the position assigned to Owenat is only 20 miles out. Rohlf's astronomically determined position for Kufara was shown by Hassanein Bey to be 25 miles out.

The interest of the volumes by Hassanein Bey and Mr. King gains not a little from reading them side by side. One gets, as it were, an inside and an outside view of native character and psychology. Both explorers had to carry through their plans in the face of Senussi opposition. It needed Hassanein Bey's admirable tact for success, even with all the circumstances in his favor. From the beginning the Senussi put a spoke in Mr. King's projects. He has a good deal to say about their machinations. Hassanein Bey can speak of them sympathetically, and he seems to put his finger on the real point at issue—that the basis of their antagonism is the instinct of self-preservation. "If a single stranger penetrated to Kufara it would be as the Bedouin says, 'the camel's nose inside the flap of the tent.'"

Regulation of the Waters of the Nile. Increased agricultural production in the Sudan has naturally meant increased consumption of the water of the Nile for irrigation, and, while during most of the year there is more than sufficient water for any immediate irrigation demands of both Egypt and the Sudan, the water supply from March to July is frequently inadequate for the summer crops. Since the low year of 1913–1914, it has been realized that development of the cultivable area of the Nile basin will require, in addition to the storage of flood water for the low season, the storage of water in good years to cover the deficiency in years of low supply. The present question is where to undertake this necessary regulation of the Nile waters.

The Lake Plateau basin and the Abyssinian highland constitute the double source of the waters of the Nile. The Lake Plateau basin is of importance because from this area comes a large part of the low stage water supply. Hydrological information on this area must be obtained as a basis for (1) a competent forecast of the amount of water during the low season on which the possible area of summer crops is based and (2) plans for storage or controlling works. A mission in charge of Mr. H. E. Hurst began an investigation in 1924, when general information was acquired on the physiography of the area in connection with its hydrology and climatology (H. E.

Hurst: The Lake Plateau Basin of the Upper Nile, *Egyptian Ministry of Public Works, Physical Dept. Paper No. 21*, Cairo, 1925).

In contrast to the Lake Plateau region the waters of the Blue Nile, or Abbai as it is locally known, arrive in Egypt during the flood period. A project involving Lake Tana as a reservoir for the storage of some of this water for use in the low season or occasional low year is seriously contemplated by the British Government. Expeditions to the lake were undertaken in 1902, 1915, and 1920. The comprehensive results of the last expedition have been published in a "Report of the Mission to Lake Tana 1920–1921," by G. W. Grabham and R. P. Black (Ministry of Public Works, Cairo, 1925). This work and the one mentioned above are profusely illustrated and form valuable contributions to the geography of the two regions. The expedition of 1920 to Lake Tana, in addition to studying the hydrology of the lake and of the stretches of the Blue Nile immediately below the lake, formulated detailed plans for its conversion into a reservoir. It was determined that the discharge of the lake made no difference either in the amount of silt or the height of the flood at Aswan and that consequently the lake might be used as a reservoir for the dry season. Lake Tana, formed by the damming of the Abbai by a comparatively recent lava flow, could be controlled by the construction of three barriers, one acting as a controller; by the cutting down of the cataract sill; and by the excavation of a tunnel and a channel in the river below the lake. Such works would allow an annual storage of 3500 million cubic meters, while a remaining 2700 million cubic meters would provide a reserve for a low year. There are numerous difficulties attending such a project, since the work would be outside British territory and would be expensive because of the difficulty of access and lack of local materials for construction. However, that the British Government is clearing the way for such an undertaking is shown by the recent convention between Great Britain and Italy. Great Britain, by agreeing not to interfere with the projected plan of an Italian railway from one of the Italian colonies in East Africa to Addis Ababa, receives a free hand in negotiations with Ethiopia on the subject of using Lake Tana as a reservoir for the regulation of the waters of the Nile (*The Times Weekly Edition*, April 22, 1926, p. 324).

Bridging the Zambezi. Among the less developed sources of raw material within the British Empire the Nyasaland Protectorate is one of the more promising. Here cotton can be successfully grown, as well as tea, maize, and sisal. A large and industrious native population solves the so-often difficult labor problem. At present the agricultural value of the Protectorate is more potential than actual, and to obtain employment many of the natives are forced to labor outside the colony.

The question arises as to why Nyasaland products are not being produced on a larger scale. The answer lies in part in the difficulty of exporting bulky goods from the colony owing to the character of the rivers of that region. In its lower course the Zambezi is a shallow stream varying in width from three-quarters of a mile to four miles, difficult to cross at one season because of the floods and at another because of low water. Until 1908 the water route via the Zambezi and Shiré Rivers was the only means of access to the country. Since that time variations in the level of Lake Nyasa and shoals in the rivers have rendered navigation increasingly difficult until, at present, river steamers are unable to ascend beyond Chindio. To overcome this situation a railroad was built from Blantyre, where most of the European planters are located, to Chindio. The difficulty and expense of handling bulky products when transshipment is necessary from railroad to river steamer and thence to coastwise steamer before ocean transportation at Beira is reached can be easily understood. To alleviate this situation the Trans-Zambezi Railway, connecting the south bank of the Zambezi at a point opposite the town of Chindio with the Portuguese port of Beira, was opened in 1922. The ferry on the Zambezi then became the only break in a continuous journey from Blantyre to Beira. Low water and floods, however,

render the ferry crossing most unsatisfactory and have successfully precluded any great amount of bulky exportation from Nyasaland.

To overcome this handicap it is proposed to connect the two sections of the railroad by bridging the Zambezi. The present plans call for a main bridge of about three-quarters of a mile which, with the approaches, will have a total length of over two miles. The estimated cost is about £800,000 (G. H. Lepper: Bridging the Zambezi, *United Empire*, Vol. 16 (N. S.), 1925, pp. 714–717). There are many problems in connection with financing such a project. Financial guarantees from the British Government must be had until the road can become self-sufficient. Early remuneration may be expected from the coal fields near Tete, which, by the construction of a branch line to the Trans-Zambezi Railway and by the construction of the Zambezi Bridge, will be brought into direct communication with Beira. This coal is of the type known as bunker coal and would find a ready market at Beira.

ASIA

Fur Seals of the Commander Islands. The period originally stipulated in the convention concluded in 1911 between the United States, Great Britain, Russia, and Japan for the regulation of the fur-seal industry has elapsed, and Japan has hinted that a new agreement would be acceptable to her. This reopens the international phase of an industry so valuable to the United States that it has reimbursed the Government for more than seven times the original purchase price of Alaska (A. H. Brooks: The Value of Alaska, *Geogr. Rev.*, Vol. 15, 1925, pp. 25–50).

Potentially almost as great a source of revenue as the American, the Russian seal industry of the Commander Islands has not prospered to any like extent. Pelagic sealing, first legalized in 1892 and continued until 1911, is the basic cause for the depletion of all North Pacific fur-seal herds. By this form of sealing, the animals were killed not only on their annual migrations to and from the islands but also on their shorter feeding excursions. As did the United States, Russia in 1892 entered into an agreement with Great Britain in a vain attempt to regulate pelagic sealing. The provisions, less strict than for the American side, proved entirely inadequate. The treaty was rendered more useless by the fact that Japan was not a party to it and that Japanese ships were particularly active in the Asiatic sealing industry. Even when the pelagic catch itself began to diminish, the Japanese were able to continue in the business because of their cheaper labor and outfit. The Russo-Japanese War of 1904–1905, which rendered Russia impotent in the Pacific, gave the Japanese an excellent opportunity for conducting wholesale raids on the Commander Island rookeries. In 1911 negotiations between the United States, Great Britain, Russia, and Japan resulted in the abolition of pelagic sealing and the institution of a sea patrol. The fur-seal herds immediately began to increase and have continued to do so. The Russian herds, however, have been greatly handicapped, because the Soviet Government has not provided any adequate protection against the seal pirates, largely Japanese, who, therefore, find a lucrative business.

Leonhard Stejneger, head curator of biology at the United States National Museum, has been sent on five separate scientific expeditions between the years 1882 and 1922 to study the condition of the North Pacific fur-seal herds. The results of his last study and a brief résumé of the history of sealing at the Commander Islands may be found in his "Fur-Seal Industry of the Commander Islands, 1897 to 1922," *U. S. Bur. of Fisheries Doc. No. 986*, Washington, 1925.

THE OCEANS

The Tides at the Entrances to the Panama Canal. Though little more than thirty geographic miles apart as the crow flies, the Pacific and Atlantic entrances

of the Panama Canal have totally different tides. At the Atlantic Ocean entrance the tide has an average rise and fall of less than a foot, with a maximum of less than three feet, and generally there is but one high and one low water in a day. At the Pacific Ocean entrance there are two high and two low waters during a day, the average rise and fall being over 12 feet, and at times over 20 feet.

In an article entitled "Panama Tides" (*U. S. Naval Inst. Proc.*, Vol. 52, 1926, pp. 660–664) R. Z. Kirkpatrick, chief hydrographer of the Panama Canal, describes the tides at the two entrances to the canal. Precise leveling between bench marks gives a difference of 0.68 foot in the mean sea level at the entrances, the Pacific Ocean entrance being the higher. This difference, however, varies throughout the year because of a difference in the annual variation of sea level at the entrances. The curves of average annual variation given by Mr. Kirkpatrick show a minimum difference of a little over one tenth of a foot in February and a maximum difference in June of very nearly one foot. The higher level of the Pacific Ocean entrance Mr. Kirkpatrick thinks is probably due in part to the effect of the meeting near Cape Mala of the southbound California Current and the northbound Humboldt Current.

H. A. MARMER

GEOGRAPHICAL REVIEWS

Power Resources of The World

The Transactions of the First World Power Conference, London, June 30th to July 12th, 1924. Vol. 1, Power Resources of the World Available and Utilised, xxi and 1506 pp., maps, diagrs., ills.; Vol. 2, Water Power Production, Preparation of Fuels, Steam Power Production, xv and 1599 pp., maps, diagrs., ills.; Vol. 3, Internal Combustion Engines, Gas and Fuel Section, Power from Other Sources, Power Transmission and Distribution, Standardisation and Research, Illumination, xiv and 1502 pp., maps, diagrs., ills.; Vol. 4, Power in Industry and Domestic Use, Power in Electro-Chemistry and Electro-Metallurgy, Power for Transport, Economic Aspects of Power Resources, Education, Health, Publicity, xvii and 1816 pp., maps, diagrs., ills.; Vol. 5, Index, compiled and edited by W. R. Douglas Shaw, 590 pp. Percy Lund, Humphries & Co., Ltd., London. 10 x 6½ inches.

The first World Power Conference opened its sessions at London, June 30, 1924. Its objects were "to survey the power resources of each participating country and the extent to which they had been utilized; to consider the technical problems involved and what steps, if any, could be taken to provide adequate opportunities for the co-operation of all nations in the development of power resources and the economic, political and educational issues involved." The first volume treats a number of geographical problems, the remaining volumes deal chiefly with technical questions. In brief, the transactions present both a comprehensive and a detailed discussion of water powers, fuels, and related problems of transmission and transportation. There are detailed maps for most of the countries represented and statistical tables that supply the latest information. Volume 1 is a compendium or encyclopedia of information concerning power and is a work of reference of a high order. We can best illustrate its character by referring to a number of specific geographical problems with which it deals.

Before the World War the world's production and consumption of coal doubled in twenty years, and there is a fresh discussion of the meaning of this tendency in terms of post-war conditions. The real question is not the total amount of coal reserves but how long cheap coal will last and how it is distributed regionally. For example, Great Britain has sufficient coal to last her from 450 to 600 years; France has a very small supply by comparison; Switzerland has practically none; North America has enough for 2000 years. But of course with a waning supply industrial decadence sets in (unless other sources of power are discovered or developed), and the figures given above must then be increased. If the generalization is true that coal not only holds the field but will long continue to do so as a general source of energy, then the distribution of remaining reserves in the face of a waning supply may be a matter of great industrial, political, and social importance. Not only coal and water-power but also tides and winds are considered. A Dutch engineer thinks that the idea of recovering energy from the tides is illusory and implies defeat of recent projects of this sort in Holland. He lives in a land of little coal and low-gradient rivers and sees hope in international peace and the free flow of commodities (including coal) rather than in windmills and tides and solar engines. Australian engineers, on the contrary, point to the tides of twenty to twenty-five feet on a portion of the coast of Queensland and in Western Australia as sources of recoverable power.

It is interesting to learn that there is much less coal in China at workable levels than had formerly been believed. Its reserves constitute only two per cent of those

of the United States, 33 per cent of those of Great Britain. In addition, the standard of workability is low on account of the primitive state of transportation. The striking computation is made that if the industrial development of China were at the level of Great Britain, that is if it called for a consumption of six tons per person per year, the full Chinese coal reserves in the face of a present population of four hundred millions would last for *fifteen years;* whereas at the present rate of consumption they would last two thousand years! Italy has a special problem in that her northern mountains have their winter precipitation in the form of snow stored up for the season, during which time there is a small stream flow, whereas central and southern Italy have little or no snow, and the flow is large in winter, small in summer. This requires two different types of engineering practice if stream flow is utilized. Water is at a premium in the new colony of Rhodesia. Public and storm waters are vested in the state. Apportionment of water for industrial and irrigational uses is made by a water court. Rights revert to the state if not used. Irrigation is a secondary use of water; industry makes but a tertiary claim. Primary uses are for domestic purposes and for stock and must be left undisturbed. A hydrographic survey is maintained in the department of agriculture.

A good deal has been said in recent years about the rise of modern machine industry in the Far East and India. In India it is the policy of both general and local governments to foster local, indigenous industries. To this end water-power surveys are under way. Especially important are the Western Ghats. They have a steep descent of about 1800 feet toward the west. At the top, 200 to 300 inches of water falls in a narrow zone during the three months of monsoon rains. By impounding the intense seasonal rainfall and permitting its slow discharge through pipe lines to the foot of the descent, a steady supply is provided for cotton and other factories on the coastal plain. Irrigation uses are of predominating importance in most sections; and "government" in India to most people means the local irrigation officer.

There is an informing discussion, in Volume 4, of the work of the International Joint Commission on water powers of interest to Canada and the United States. By the Treaty of 1909 these two countries sought to prevent disputes or to settle them with respect to "boundary water." There are an equal number of Canadians and Americans on the Commission, and in the seventeen years it has existed four major questions have been settled with substantial accord as to all conclusions and recommendations. Among the questions treated is that of the St. Lawrence and the means whereby a maximum development of navigation and water power may take place in the upper part of the river. The spirit of good will as well as the close commercial relations of the two countries has brought about an almost ideal settlement of common problems of power and has rightly been held up as an example to the rest of the world.

The British Isles

J. Moscheles. **Landeskunde der Britischen Inseln.** 104 pp.; maps, diagrs., bibliogr., index. (Enzyklopädie der Erdkunde.) Franz Deuticke, Leipzig and Vienna, 1925. 4 gold marks. 10 x 7 inches.

"Landeskunde der Britischen Inseln" would appear to be designed primarily for German university students as a textbook and guide for further reading; and for the present purpose we may consider it as such. The author has evidently taken her task seriously and has exhibited much diligence in ransacking the literature, at least that which bears upon structure and land forms, and has succeeded very well throughout in compressing much information into small compass.

General aspects occupy the first part: the second part gives accounts of ten subregions. A chapter in the first part deals with paleogeography; and this geological matter is supplemented by considerable physiographic treatment in all of the re-

gional sections, with the result that well over one quarter of the book is given to geomorphology. This is a heavy proportion, especially as there is small attempt to help the reader to visualize the landscapes in any of their characteristic details, the space being used rather to state various theories of origin. Nevertheless, the author has provided a very useful digest of physiographic literature, with many references, and in places has not hesitated to give her own interpretations.

Of the general chapters that upon climate appeals to the reviewer as a particularly good statement; it would, however, be improved by some account of the characteristic weather sequences. Flora and fauna are discussed only in relation to their probable origins, and natural vegetation receives but scant mention in the regional sections as an element in the landscape. The leading features of British agriculture and fisheries are presented satisfactorily on the whole. Throughout the book, industry and trade are handled in an interesting manner. Economic facts are well selected and given in their proper historical setting. The location of industries is nearly always discussed with due mention of geographical controls and without undue straining of these. In regard to statistics as well as to movements Dr. Moscheles does not confine herself to pre-war conditions, and the book thereby gains in utility. One could wish that the references to sources were as numerous in this part as they are when related to physiography.

Since so much has been achieved in so few pages, it is scarcely reasonable to point out omissions. But compression inevitably leads to eliminations that in places detract from the picture. For instance, the view of the dry thinly-peopled chalk downs serving only as sheep walks (p. 80) is incomplete; for great tracts of these uplands are covered with heavy residual clays that form either arable land or woodland. We are informed by implication that whiskey replaces beer in Scotland (p. 24) because barley does not thrive there. The fact is that Scottish barley, which is excellent, is largely used in making malt for whiskey. Or again, the use in several places of a name such as the "Waverley Route" (one of the railways leading from England through southern Scotland) may be misleading to foreign readers who may be led to accept as of ancient origin a name that arises only from associations with the home of Sir Walter Scott. In a reference (p. 76) to the older universities of England (Oxford and Cambridge) the author appears to have been misled by a failure to realize the meaning of the nomenclature in the statistics used.

Clearly Dr. Moscheles has not merely compiled information and in general presented it well but has also thought about it and has often drawn her own conclusions. She rightly ends her book with an indication that the human geography of Britain must be considered in relation to the Empire, of which she says: "A people which gains as brothers in arms its enemies of a few years ago—the Boers—has certainly the faculty not only of creating an Empire but also of holding it."

ALAN G. OGILVIE

PLANT GEOGRAPHY OF SWITZERLAND

ERNST FURRER. **Kleine Pflanzengeographie der Schweiz.** viii and 331 pp.; maps, diagrs., ills., bibliogrs., index. Von Beer & Co., Zurich, 1923. 8 x 5½ inches.

A quarter of the surface of Switzerland is in forest. Flury's dictum that 37 per cent is necessary to satisfy a country's needs leaves it needing to import lumber, but surely the scale of consumption matters. Three quarters of the forests are protective, guarding against avalanches and erosion. The law forbids diminishing this protection. Actually the surface in forest is increasing.

Swiss experience is said to have demonstrated that clean cutting of forest and replanting with a solid growth of pine, for instance, has been a mistake. For 50 or 60 years the trees thrive, but after that they do not grow well and are exceedingly liable to red rot (Rotfäule). Often the country people are still devoted to this type

of lumbering. The experts prefer a forest of mixed types and ages, from which individual trees are cut without opening clearings for wind and frost to enter, the young trees replacing the old as fast as they are removed. Of the expense of getting out trees in that way nothing is said.

Seventy per cent of the trees of the Swiss forests are conifers, growing high up mainly and on the rougher ground. On the lower, smoother, and better ground grow the remaining 30 per cent of hardwoods. Twenty-five per cent of them are beech, a tree which demands the soft, moist, nourishing soils, which it is inclined to monopolize. The most prevalent Swiss forest group, the common spruce, occupying 40 per cent of the wooded surface, yields the best lumber, prized for the evenness of the annual rings and the fineness of the grain. It occurs on rough, high ground above the beeches, where the moisture content is moderate, in the highest parts of the Jura, and on the high Alps at elevations between 1000 and 2000 meters.

Besides the forest associations some thickets are listed, some moors, and eleven sorts of meadows.

While a fourth of Switzerland is still covered by forest, it would be two-thirds wooded if it were not for man. Thanks to much moisture the country is everywhere green. Eighty-five per cent of the surface has over 850 millimeters of rain a year. Man has taken much good land away from the forest to till, but since the middle of the last century he has been turning tilled land back into grass. Since the railroads and steamships made transportation general it has been easier for Switzerland to import grain than to raise it. The labor needed to produce milk is more comfortable and allows grain to be bought with advantage to all concerned. People get along better here than in "the good old days" when the grain was produced at home. This is the usual case, though it is true the country is less "self-sufficient," whatever that may signify. The cattle of the country get their food mainly from the hayfields which up to a height of 1000 meters yield two crops. Occasionally a second crop may be cut up to 1600 meters. The Alps proper—the mountain pastures—contribute not more than a seventeenth of the cattle food, and much harm is done by overgrazing them. One wonders if they pay for the labor attendant on their use.

There is a considerable variety of other matter concerned with plants in this valuable little book, the aesthetic element not being at all neglected. The halftones of plants and landscapes are excellent. The author has the courage to call them "pictures"—Picture 1, Picture 25. There are no "figures" in the book; and the frontispiece, Plate I, contains Pictures 26, 41, and 42—a commendable innovation.

This is just the book to pack with the Baedeker when next you go to Switzerland.

MARK JEFFERSON

PIONEER HISTORY OF GUIANA AND SOME WEST-INDIAN ISLANDS

J. A. WILLIAMSON. **English Colonies in Guiana and on the Amazon, 1604–1668.** 191 pp.; map, index. Clarendon Press, Oxford, 1923. 9 x 6 inches.

V. T. HARLOW, edit. **Colonising Expeditions to the West Indies and Guiana, 1623–1667.** xcv and 262 pp.; maps, ills., bibliogr., index. *Hakluyt Soc. Publs.*, Series 2, Vol. 56, London, 1925. 9 x 6 inches.

The former of these two books is a valuable contribution to the early history of pioneer Englishmen in that part of Guiana where attempts were made to trade and set up depots when there were no real settlements. We may object to the title "English Colonies," for these attempts were not national or in any sense real colonies. They were trials and experiments by Englishmen without authority from the Government and not strictly national. This is conspicuous in all the earlier pioneer work in the West Indies—the work was attempted by and for the individuals concerned. There were no colonies of any nation in Guiana before Surinam was

started as an offshoot of Barbados; even then it was a private adventure of Lord Willoughby.

There is in this book also a suggestion of partiality, for Englishmen were not alone when many attempts were made to trade with the natives at the mouth of the Amazon—Dutchmen and Frenchmen were quite as prominent. Some of the old charts have the names of towns which were supposed to have been destroyed by Portuguese, though even the pioneers of that nationality could hardly be called anything but adventurers. There was a kind of rivalry, but it was of the nature of business competition, and in the earlier times there were friendly relations with these rivals. Thus, to understand the position a writer must take in the whole field.

It is a curious fact that the part of Guiana in which pioneer work was done and in which failure always ensued has not even yet been developed by Brazil, though she successfully contested its boundary with France. It makes one smile to think of the Grand Republic of Counani of forty years ago which claimed the area in which the English, Dutch, and French pioneers adventured their savings as well as their lives. The projectors of Counani looked upon the district as a "no man's land," and it is much the same today.

The Hakluyt Society's volume should be extremely interesting to colonists of the West Indies and Guiana. Though its contents are not new to the historical students of British Guiana, it is an advantage to have them brought together and published in the excellent way of the Hakluyt Society. The greater portion of the manuscripts was copied by the late Mr. N. Darnell Davis and published in local newspapers, where of course they are hidden from those unacquainted with Mr. Davis' work.

The manuscripts here copied and edited came from several sources, including the British Museum, and are valuable for the light they throw upon the early settlers and their settlements in St. Kitts and Barbados, besides Tobago and Surinam. Sir Henry Colt's account of his voyage gives us a series of views of Barbados and St. Kitts about four years after the settlements were started. To those who know the Barbadians of today the views and opinions of Sir Henry Colt are peculiarly interesting because the infant colony was the germ from which came the man who is neither "Carib nor Creole, but true Barbadian born."

We are reminded in other places in the book of the fact that Barbados was responsible for the colony of Surinam which was an offshoot and perhaps unique from the fact that it was planted without the assistance of the mother country and was not recognized as English until fairly prosperous. The colony of Barbados planted its own colony on the mainland!

A fair portion of the book consists of accounts by Major John Scott, who may be called a Barbadian as well as an arrogant boaster. He headed a party of Barbadians to an attack on the Dutch settlements of Pomeroon and Kyk-over-al, and in retaliation the Dutch captured Surinam, which was ultimately ceded at the peace in exchange for what is now New York. Those who are interested in the history of the connection of Barbados and Guiana can find much food for thought in these old manuscripts, and we who know something of Barbadians from actual contact in British Guiana are amused to see how they have retained their character for three centuries. Throughout these centuries Barbados has often influenced British Guiana in spite of her loss of Surinam.

The first settlers in St. Kitts had many difficulties with the Caribs. Barbados was, however, quite free because the island had long been deserted by its original inhabitants and had not been invaded by the Caribs. In this and in some other respects Barbados stood alone. The island has never changed hands: she was English from the first and remained so through all the upsets that made the other islands as it were shuttlecocks between England and France.

This curious position as an uninhabited island has puzzled the archeologist, and we may be pardoned for trying to throw a tiny ray of light on the matter. It is

evident that there were once people of the Arawak stock in numbers and that they lived there long enough to learn how to make pottery and to grind down conch shells to make celts. These people were similar to those of Hispaniola and Porto Rico; they probably had their petty quarrels but were peaceable until the Caribs came to bring confusion and, as some people say, to exterminate them. What we suggest as most likely and in accordance with fuller knowledge is that the Caribs killed a great number, but there were fugitives who worked their way down to the mainland to form the Arawaks so well known in Guiana. It may be suggested that the early Barbadians helped to fight the Caribs in some other islands and escaped with the remnant.

The Portuguese who first named the island put ashore a pair of hogs, and the result was that the first settlers had pork to waste, as Sir Henry Colt tells us. Evidently no hunting parties of Caribs ever visited the island or the pigs would have been exterminated or of little account. The people left Barbados before it was discovered by Europeans and had never returned.

JAMES RODWAY

DESERT STUDIES

JOHANNES WALTHER. **Das Gesetz der Wüstenbildung in Gegenwart und Vorzeit.** 4th edit. xv and 421 pp.; maps, ills., index. Quelle & Meyer, Leipzig, 1924. 16 mks. 9½ x 6½ inches.

W. F. HUME. **Geology of Egypt, Vol. 1: The Surface Features of Egypt, their Determining Causes and Relation to Geological Structure.** With preface by H. G. Lyons. xliv and 408 pp.; maps, diagrs., ills., bibliogr., index. Ministry of Finance, Cairo, 1925. 50 P. T. 11 x 7 inches.

To all students of deserts the appearance of these related volumes is an event of the first order of importance. Professor Walther has long been the most cosmopolitan of desert travelers and has probably seen and studied in reconnaissance journeys a greater number and variety of desert areas than any other geologist. On the other hand, Dr. Hume, who for nearly a quarter of a century has been geologist and latterly director of the survey of the most arid area upon the globe, has been engaged in detailed and thorough studies of desert conditions. Notwithstanding the wide range of his travels, Walther has devoted far more of his attention to Egypt and the Anglo-Egyptian Sudan than he has to other regions; and about two-thirds of the 203 excellent illustrations with which his book is embellished have been taken from photographs made within the contiguous desert areas of Arabia, Sinai, Egypt, and the Sudan. It is Walther's special merit that he early saw and emphasized the work of the wind in desert processes, since this work has been, and still is, consistently ignored by nearly all American geologists, including those who made the now classical studies of American desert regions.

The testimony of Hume in the monumental work that has now come from his pen is also to emphasize most strongly the rôle of the wind, which in erosion and transportation for the desert areas to the west of the Nile has worked almost unaided. In the areas to the eastward, Arabia and Sinai, the ephemeral water torrents from cloud-bursts have carved out the numerous canyons with their boulder-strewn beds. Hume, it should be pointed out, has described definite areas of desert which he knows intimately, whereas Walther has made his generalizations apply to all desert areas indiscriminately. To the reviewer it seems that he has ascribed far too little importance to the work of the rains within such semiarid regions and "arboreal" deserts as the southwestern United States and neighboring portions of Mexico. Lawson, Powers, and Bryan have shown convincingly that within this broad region, which is only semiarid, the features that evolve in definite sequence reveal profiles in the main shaped by the rains, even though these are as the reviewer believes modified by wind action in a manner of which they have taken no account.

By ignoring these important studies Walther has marred the value of a work which must always be taken into account by anyone who would pursue seriously the subject of desert geology. As one reads the picturesque language and reflects upon the sweeping statements of this German savant, it is clear that he has not weighed his evidence as carefully as the wide range of his studies would lead one to expect. Furthermore, one cannot pass over reference to a more serious criticism in quite another quarter, i. e. his amazing remark in the introduction on the German invasion of France.

The volume by Hume is a monumental piece of work which for the first time brings within the compass of a single cover a wealth of facts gathered by a keen and careful observer who has had opportunities probably never equaled to know intimately the most perfect examples of rainless districts. The material has been well organized, and a wealth of well-selected and very striking illustrations has been added. The chapter headings afford some notion of the wide scope of the inquiry. These are: Egypt: A Land of Contrasts, Temperature Variations and Their Results, Wind Effects and Sand Action, Effects of Rainfall in the Desert Regions, Chemical and Physical Activities Due to Solution and Evaporation, Frost and Ice, Marine Erosion, Plant Effects.

Mr. E. H. Keldani, of the Egyptian Survey, has supplied to the volume an extremely full and valuable bibliography of geological literature relating to Egypt which covers no less than 67 imperial quarto pages.

WILLIAM HERBERT HOBBS

PHYSICAL GEOGRAPHY OF THE GOLD COAST

GUSTAV GAST. **Die Britische Kolonie Goldküste: Eine physisch-geographische Studie.** 93 pp.; map, bibliogr. Reprint from *Mitt. Gesell. für Erdkunde zu Leipzig* 1919–1922.

This painstaking doctoral dissertation is confined to the physical geography of the Gold Coast (including Ashanti and the Northern Territories), and in the main it adheres to the divisions that have become standardized in German writings—location, geomorphology, hydrography, climate and meteorology, vegetation, and animal life. This matter is frankly intended to serve as a basis for subsequent investigation of the "human geography" of the area, although a brief section on economic geology and a five-page summary of peoples anticipate this intention to some degree, and interesting bits of human geography are scattered through the whole study.

Since the Gold Coast is a cross section of Upper Guinea, a detailed investigation of its natural environments should throw much light on the region as a whole; and the wealth of facts set forth in this slender volume does afford a valuable basis for comparison and contrast with other lands between Portuguese Guinea and Cameroons. The projected companion volume on the human life of the area as related to the natural environment is to be eagerly awaited.

D. S. WHITTLESEY

THE DROUGHTS OF NORTHEASTERN BRAZIL

J. DE SAMPAIO FERRAZ. **Causas provaveis das seccas do nordeste brasileiro.** 30 pp.; maps, diagrs. Minist. da Agric., Indust. e Commerc., Direct. de Meteorol. Rio de Janeiro, 1925. 10 x 7 inches.

Dr. Ferraz believes that rains in northeastern Brazil occur with a cold upper current originating to the south or southwest in an anticyclone in southern Brazil or the northern Argentine. This, he says, causes an unusually large vertical temperature gradient, on which the rainfall is dependent. But when the nearest anticyclone is far away in the southern Argentine and only cyclones appear in southern-

most Brazil and northernmost Argentine, the vertical temperature gradient is small, precipitation is not produced, and drought prevails.

Local causes, he says, are not to be found for the drought, since heavy rain and acute drought occur with identical local conditions except that there are stronger winds in time of drought. Diagrams of years of rain and years of drought do not help because of the illegibility of their legends, nor are they self-explanatory. No observations on upper air temperatures and movements have been made in northeast Brazil; but in Cuyabá, some 1600 miles to the southwest, "we found frequent cases of the winds referred to up to 6000 meters . . . and we ascertained immediately that these currents were in most cases moved by the anticyclones which are in the habit of crossing the South American continent between the extreme south of the Argentine and the 20th parallel." I quote this passage because I do not like to restate it and because it shows the style of Dr. Ferraz's arguments from observation, which are vague and, by not putting observations before the reader, prevent him from drawing his own inferences.

Dr. Ferraz states that there are no exceptions to the concurrence of droughts in the northeast of Brazil and low pressure areas in Matto Grosso and of rain with anti-cyclones there.

The present reviewer would have liked to learn why the interior is so much drier than the coast, why scanty rainfall is less than two hundred miles removed from excessive rainfall in the average of the record; but the drought Dr. Ferraz is explaining is temporal, not spacial—the dry years that affect the whole region and are a veritable calamity every few years in Ceará.

Dr. Ferraz hopes to explore the upper air of northeast Brazil and check up on his theory.

MARK JEFFERSON

THE POLAR LANDS

LUDWIG MECKING. **Die Polarländer.** xii and 158 pp.; maps, diagrs., ills., bibliogr., index. (Allgemeine Länderkunde.) Bibliogr. Inst., Leipzig, 1925. M. 9.50. 10 x 7 inches.

HANS RUDOLPHI. **Die Polarwelt.** 144 pp.; maps, ills., bibliogr., index. (Jedermanns Bücherei.) Ferdinand Hirt, Breslau, 1926. M. 3.50. 7½ x 5 inches.

OTTO NORDENSKJÖLD. **Nord-und Südpolarländer.** HANS RECK. **Island und die Färöer.** xii and 85 pp.; maps, diagr., bibliogr., index. (Enzyklopädie der Erdkunde.) Franz Deuticke, Leipzig and Vienna, 1926. M. 5. 10 x 7 inches.

When a scholar of excellent judgment, with his eye on the woods (and who knows the trees thoroughly) produces a *small* book it is a notable event: such are Gautier's "Le Sahara" and Siever's "Die Cordillerenstaaten," and such is Mecking's "Die Polarländer," listed above. Mecking has everywhere sought out ideas and discussed them impartially. The German style of type is used, trying to the eyes and difficult to inspect when one goes from index to text to locate proper names: the page must be searched repeatedly. Italics or bold face would have helped. There are two excellent color plates for the polar areas. About the north polar map is run a line indicating the limits of present occupation or development. A table gives the most northerly positions reached by Arctic explorers between 1587 and 1925. Well selected text maps and photographs are included.

Mecking draws impartially upon the literature, but Rudolphi by avowed intention has not a single foreign (therefore no English, French, or Russian) title in his bibliography. The result is a bit weird. It results that Scandinavian authors are freely referred to because their work has been published in German in so many instances. Peary, Parry, Shackleton, Scott, Stefansson, and Leffingwell—to take names at

random—are thus formidably omitted, and one wonders why such a principle was followed. To cover the two polar regions in a small book of 144 pages, 7½ x 5 inches, is of course an heroic undertaking. There is really no room for critical appraisal and no time for following new trails. The photographs are admirably chosen. Certainly the convenience of the tabloid plan of Jedermann's Bücherei is well illustrated by Rudolphi, and the price is fixed for the multitude.

In attention to ideas, Nordenskjöld's essay is noteworthy. Greenland and Spitsbergen and other large land elements are specially discussed, and the comments upon individual explorers and their results are both catholic and penetrating. Mecking and Nordenskjöld together supply a brief and useful statement of the state of polar research and the outstanding facts and ideas in the geography of polar lands.

Tropical Cyclones

S. S. Visher. **Tropical Cyclones of the Pacific.** 163 pp.; maps, diagrs., bibliogr. *Bernice P. Bishop Museum Bull. 20*, Honolulu, 1925.

S. S. Visher and D. Hodge. **Australian Hurricanes and Related Storms, with an Appendix on Hurricanes in the South Pacific.** 54 pp.; maps. *Commonwealth of Australia Bur. of Meteorol. Bull. No. 16*, Melbourne, 1925.

Norbert Fischer. **Die wirtschaftlichen Schäden der tropischen Wirbelstürme: Eine wirtschaftsgeographische Untersuchung zur Frage der Wirtschaftsinstabilität infolge von Wetterschäden.** 54 pp.; map, bibliogr. *Aus dem Archiv der Deutschen Seewarte*, Vol. 43, 1925, No. 1, Hamburg. 11 x 9 inches.

Professor Visher has for the past ten years devoted much study to tropical cyclones, including field work in Hawaii, Fiji, southeastern Australia, and the Far East from 1921–1922. The result in these two monographs is a comprehensive discussion of the tropical cyclones of the whole Pacific area—in reality a textbook on this subject which serves to fill a very considerable gap in meteorological literature. Professor Visher has for the first time clearly brought out many of the human and economic relations of tropical cyclones, so that his monographs will prove valuable to teachers and students of geography as a whole and not solely to professional meteorologists. In fact, these publications are distinctly interesting reading, containing vivid descriptions and well-selected quotations from personal experiences and from ships' logs.

The first-named of the two discussions here considered begins with a general description of tropical cyclones and their effects and includes thermograph and barograph curves recorded during passages through the "eye," where, in several well-authenticated cases, a rise of temperature was recorded in the central area—unmistakable evidence of adiabatic warming of descending air currents in the midst of the whirling "hurricane" winds around the center. The distribution and frequency of tropical cyclones are discussed at considerable length. In the case of the recorded hurricanes in the South Pacific, the tabulated record goes back as far as 1789. Note may here be made of the fact that the tropical cyclones of the eastern North Pacific, in the region west of Mexico, have as a whole been ignored in the usual discussions. It has long seemed to the reviewer that this group is deserving of more attention than it has hitherto received. It was a Connecticut Yankee of the middle of the last century, William C. Redfield, who first directed attention to these storms. The courses followed by cyclones are illustrated by means of several track charts, some previously published and some new, embodying the results of the author's own studies and observations. The velocity, size, duration, and intensity of tropical cyclones are considered; and the problem of their origin—a necessarily much-discussed problem, not yet at the stage of satisfactory solution—is next taken up. The various theories as to origin are presented. The author wisely concludes (p. 95)

that "not enough is known to permit of a full discussion" of many of the most important questions here concerned. The energy, causes of movements, and forecasting of these storms are further subjects to receive attention. Analysis of new compilations of available data fails to disclose "any striking correspondence between the annual frequency of tropical cyclones and the spottedness of the sun" (p. 106).

The discussion covering the human and economic relations is especially important from the larger geographic point of view and sets forth several aspects not hitherto given adequate attention. The winds not only damage buildings but often seriously injure crops. In these days of increasing dependence of the "temperate" latitudes upon tropical foodstuffs, such as sugar cane, fruits, coffee, etc., this element in the problem will attract increasing notice. There may be some difference of opinion regarding Professor Visher's view that "tropical cyclones apparently tend to increase the inertia of tropical peoples, strengthen their faith in fatalism and communism and to favor the spread of disease." The author, however, gives numerous illustrations to support his view. The dispersal of life from island to island, it is believed, may have been partly due to the agency of cyclonic winds. Many of the irregular changes in the weather of mid-latitudes are thought to be "profoundly" influenced by tropical disturbances—a point not hitherto considered, certainly in any detail. Some practical suggestions for reducing the damage by tropical cyclones are given, such as the selected location and proper construction of buildings; the diversification of crops; better storm warnings; insurance; etc.

The second publication, an official Bulletin of the Australian Commonwealth Meteorological Bureau, includes all the recorded data regarding the occurrence of hurricanes in Australia and adjacent ocean areas, for the benefit of marine and other interests. It is the joint work of Professor Visher and of Mr. D. Hodge, of the Commonwealth Bureau of Meteorology, Melbourne, Professor Visher having been temporarily connected, in an honorary capacity, with that Bureau while he was carrying on his researches on the tropical cyclones of the Pacific.

Dr. Fischer has had access to the great storehouse of material in the libraries of the Deutsche Seewarte in Hamburg and of the Prussian Meteorological Institute in Berlin, as well as to numerous other sources of first-hand information. He has also drawn freely upon the work of Professor Visher. His paper is another indication of the rapidly growing tendency to emphasize the practical human and economic side of meteorological phenomena and not to limit consideration solely to theory or description.

It is probable that comparatively few people fully realize the extent and the variety of the destruction caused by tropical cyclones. The causes of the destruction thus wrought are three, viz. the high wind velocities, the storm waves and floods, and the torrential rainfalls. Fortunately for man these cyclones are fairly well limited as to season and regions of occurrence. This fact, combined with the forecasts now generally available in all of these regions, makes possible a certain degree of preparedness. Numerous examples are given by Fischer of the methods taken by man to decrease the amount of destruction, such, for example, as building the famous Galveston sea wall; constructing especially massive buildings, as in the case of certain exposed lighthouses; weighting down roofs to keep them from blowing away; placing dwellings on tall piles to raise them above flood level, etc. Special hurricane shutters are also used in some cyclone districts.

Certain useful and practical suggestions are given regarding the best crops to be planted in regions subject to visitation by these dreaded phenomena. The West Indian hurricane area is put first in the extent of damage done, and in this area also are seen the most striking and most general human responses. At the end of Dr. Fischer's monograph there is a tabulation of noteworthy tropical cyclones of recent years, together with estimates as to loss of life and the amount of property damage.

R. DeC. Ward

Agricultural Economic History

H. C. Taylor. **Agricultural Economics.** x and 439 pp.; maps, diagrs., index. (Social Science Text-Books, edited by R. T. Ely.) The Macmillan Co., New York, 1923. 8 x 5½ inches.

P. W. Bidwell and J. I. Falconer. **History of Agriculture in the Northern United States, 1620–1860.** xii and 512 pp.; maps, diagrs., ills., bibliogr., index. Carnegie Instn. of Washington, 1925. 10 x 7 inches.

L. B. Schmidt and E. D. Ross., edits. **Readings in the Economic History of American Agriculture.** xii and 591 pp.; indexes. The Macmillan Co., New York, 1925. 9 x 6 inches.

N. S. B. Gras. **A History of Agriculture in Europe and America.** xxvii and 444 pp.; diagrs., index. F. S. Crofts & Co., New York, 1925. 9 x 5½ inches.

The "Outlines of Agricultural Economics" by Dr. H. C. Taylor is a revision of "Agricultural Economics" published in 1919. The additions in the recent volume are to be found mainly in the chapters dealing with insurance, standardization, marketing institutions and market information, crop estimates and forecasts, co-operation, and the last chapter on the future of the farmer—all contributions from the author's experience in connection with the Bureau of Agricultural Economics. The added chapters broaden his work so that it becomes a more satisfactory text-book for a general course in the subject.

Dr. Taylor's agricultural economics is dynamic. He recognizes the fact that changes are continually occurring and emphasizes the importance of studying the factors that cause these changes. Among the dynamic forces are the geographic forces. Geographers who are not familiar with this or earlier editions may find it of interest to turn to his chapter dealing with farm organization as influenced by geographic factors (Ch. V). In this chapter he recognizes not only the physical influence of geographic conditions upon the production and handling of products but also the effect of geographic location upon costs and prices, which are fundamental economic factors in the organization and operation of a farm. Furthermore, he presents a clear statement of the influence of the extent of area suitable for the production of different crops upon farm organization. This is a very important factor in both national and international trade in farm products as well as in farm organization.

The economic geographer will find the "History of Agriculture in the Northern United States" by Bidwell and Falconer of great interest. This volume represents an intensive study of the shifts and changes in the agricultural industry of the north-eastern section of the United States before the Civil War. The westward movement of settlement and the shifts and changes in agricultural production are described in detail. Maps show the advance of settlement and changes in density of population from 1790 to 1860. Another series of maps, adapted from Meyer's "History of Transportation," shows canals in use in 1815 and railroads in operation in 1840, 1850, and 1860. The shifts in agricultural production are indicated by dot maps made from the censuses of 1840, 1850, and 1860. These maps are accompanied by discussions of the influence of geographic conditions. The work is also well illustrated with cuts of farm machinery and charts of prices. It contains an excellent bibliography which points the way to a large field of source material.

Schmidt and Ross have made a good collection in the "Readings in the Economic History of American Agriculture." They have grouped the various selections by periods and have written very good connecting introductions. The editors recognize the importance of geography in the development of agriculture in this country, but the selection chosen to present the geographical basis of American agricultural development is quite inadequate. A few maps showing topography, precipitation,

and temperatures, with supplementary text such as might have been taken from the yearbooks of the Department of Agriculture and sections of the "Atlas of American Agriculture," would have been more satisfactory than the quotation from "The Conservation of Natural Resources in the United States." Other chapters that may be of special interest to geographers are: The Westward Movement of Population and Agricultural Systems, Growth of Home and Foreign Markets, The Westward Movement of Wheat, and The Growth of the Dairy Industry and Diversified Farming. These chapters also could be greatly improved by including some maps with descriptive text such as may be found in the yearbooks of the Department of Agriculture.

"A History of Agriculture in Europe and America" is too ambitious a title for Professor Gras's book. It might have been more appropriately entitled "Chapters in the History of Rural Life in Europe and America." The author approaches the subject from the point of view of a general economic historian who has some interest in agriculture as one of the fields of economic life, and the first two chapters of his book would fit into the introduction of any textbook on economic history. About half of the book is devoted to rural life in Europe. Roman agrarian history, the medieval manor, and peasant revolts are dealt with. One of the most interesting chapters is that on metropolitan and national economy in England. Here Professor Gras has made his most definite contribution to our agricultural economic history. The idea involved is not new, except that it is here presented from the point of view of a metropolitan center or a small nation rather than from the point of view of a farmer adjusting his agriculture to a market, as originally presented by Von Thünen in "Der Isolierte Staat." It is essentially the same principle as that discussed in Dr. Taylor's chapter dealing with farm organization influenced by geographic factors. According to the author, the growth of the city is the dynamic factor in the development he describes, whereas others would give more emphasis to improvements in agricultural production and transportation.

In the section of the book dealing with the history of American agriculture more space is given to description of agriculture and agricultural operations, especially in their social and political aspects. The reader who is looking for a consecutive and inclusive story of agricultural development will be disappointed, but he who is interested in the social and political aspects of rural life will find many interesting chapters in this book.

O. C. STINE

MERCHANT MARINE AND THE AMERICAN PROBLEM

H. C. CALVIN AND E. G. STUART. **The Merchant Shipping Industry.** v and 373 pp.; maps, diagrs., ills., index. John Wiley & Sons, Inc., New York; Chapman & Hall, Ltd., London, 1925. $4.00. 9½ x 6½ inches.

A glance at the preface of this volume immediately impresses one with a point of view that is refreshing. "The authors feel that a textbook on ocean shipping need not concern itself with the details of the *pix pinus* form of charter party or the intricacies of particular average insurance. These things are not essential to the understanding of the economic reasons why some countries have no difficulty in developing merchant shipping, why some governments have thought it necessary to give aid to their merchant marines, why shipping is by nature a poor paying business, and all the myriad questions that center around shipping as an industry as opposed to shipping as a career."

In addition to the viewpoint some of the facts in this book are new, and several interpretations are not only novel but will perhaps come to be accepted as sound economic theory. The analysis of the relation between the liner and the tramp ship, based largely on studies carried on by the Department of Commerce, calls for

a revision of the current economic theory about ocean freight rates. According to late researches, the competition of the tramp with the liner has become so negligible for most kinds of cargo that the tramp can no longer be considered as a regulator of liner rates. A brief analysis of the existing theory that sailing vessels are largely used in the coasting and pioneer trades shows that such vessels are now used on the main routes of the world in about the same proportion as they have been.

The most novel feature of "The Merchant Shipping Industry" is found in the treatment of government aid. "The experience of the United States with subsidies and bounties to shipping has not been very pleasant or profitable. This fact is not due to any inherent weakness or strength in the idea of a subsidy. In common with so many other human devices, a subsidy to shipping wisely applied can accomplish its limited ends; the scheme is far from being a patent medicine cure-all. . . . The economic resources, the geographic location, and the state of industrial development of a country are of far greater weight than doles from a treasury." And again, "In conclusion it may be stated that the answer to the question: Do subsidies succeed? is not Yes, or No, but a series of counter questions: Succeed for whom? Succeed for what particular purpose? At what time in the country's development? It is puerile to attempt to apply *in toto* the experience of the countries previously discussed to our own case, as has so frequently been the case in print and in Congress." While sufficient emphasis is given to economic and geographic factors, the authors show that, after all, governments have aided shipping not for trade reasons so much as for political and militaristic purposes.

The last section of the book deals with the American shipping problem. The authors believe that the history of shipping in the early days of the republic would repay additional research. They show that the early statistics on the subject are faulty and have led to erroneous conclusions about the efficacy of some of our early legislation. The chapters on our shipping since the World War will be illuminating to most readers. After pointing out some changes which are needed, they conclude, "If these changes are made in the present situation, the chances for a permanent and growing American merchant marine are good. Slow-working causes are operating to this end. Congress should do its part in removing all artificial and unnecessary restraints." This book is designed primarily as a textbook but will be found of great benefit to anyone at all interested in one of the major problems now before our country.

I. G. MONAHAN

A TREATISE ON GEOMORPHOLOGY

GAETANO ROVERETO. **"Forme della terra": Trattato di geologia morfologica** (**geomorfologia**). Vol. 1, Basi e generalità, xiii and 641 pp.; maps, diagrs., ills., bibliogrs.; Vol. 2, Tipi regionali, viii and pp. 647–1187; maps, diagrs., ills., bibliogrs., index. Ulrico Hoepli, Milan, 1924, 1925. Vol. 1, 80 lira, Vol. 2, 70 lira. 9½ x 6½ inches.

Gaetano Rovereto, professor of geology in the University of Genoa, who among his other writings has previously given us a most interesting and detailed study of shore-line phenomena, here presents a two-volume work on geomorphology. Volume 1 is devoted to systematic geomorphology, while Volume 2 deals with "regional types." The work as a whole constitutes an important addition to geologic and geographic literature.

The first half of Volume 1 sets forth the data which in the author's opinion constitute the essential foundation for studies of land forms. Under the head of "climatic data" are considered such topics as present climatic types, climatic conditions in high altitudes, past changes of climate, and the possible causes of the glacial period.

"Lithologic data" are next discussed; and here we find a treatment of rocks and their classification, together with an account of rock structures, in which jointing, stratification, foliation, and certain grosser structures like laccoliths and other intrusive types are especially emphasized. "Biologic data" relate to organic deposits of all kinds and include a discussion of the destructive and protective action of organisms. In presenting "external dynamic data" concerning the processes operating upon the earth's surface, the author touches on the porosity of rocks; their silicification, calcification, and other chemical transformation; their decomposition; and the erosion forms which they assume under the influence of streams, waves, winds, and glaciers. Extensive regions, for example Italy or parts of South America, are divided into provinces based on the predominance of some one dynamical process, such as glacial erosion, wind action, fluvial erosion, frost action, solution, alluviation, volcanic accumulation. "Geological data," including processes operating within the earth, carry the author's discussion from such stratigraphic and tectonic problems as transgression and regression of the sea in relation to sedimentation, deposition in geosynclines, isostasy, and earthquakes, all the way to detailed subdivisions of the geologic column with lists of characteristic fossils (including particularly full tables for the Quaternary stratigraphic succession), prehistoric man and his industries, and the methods of calculating the duration of geologic time. Surely the author leads his readers into byways which, however interesting they may be, wander far from the field of geomorphology. Faults and folds are geologic structures of prime importance to the student of land forms; but of how much value to him are the various minor rock structures shown by the author in photographs of hand specimens?

With the "data of geomorphology" thus fully presented, the author turns to the second part of his work, which he terms "geomorfologia speciale," perhaps best translated "systematic geomorphology." Here, after a brief discussion of preliminary notions, we find an extended account of stream erosion and its associated processes and a discussion of the notion of the cycle as applied to land forms. Valleys are classified into various groups, among which one notes erosion valleys, pseudo-erosion valleys, tectonic valleys, pseudo-tectonic valleys. A special chapter is devoted to the character of the earth's surface as affected by geologic structure and by the initial form upon which streams have operated. Basins and lakes are similarly treated as a subject apart, while marine processes and the forms they produce are described in the final chapter of the volume. No corresponding treatment of the work of glaciers and winds appears; and one marvels the more at this conspicuous gap because Italy is rich in glacial features of striking beauty and has interests in regions where the wind is an important agent of land sculpture.

The second volume, on "Tipi regionali," discusses volcanic regions; glacial regions; karst regions; deserts and steppes; plains; hills; low and intermediate mountains; high mountains; coastal regions; uplands; and submarine depths. Such an enumeration of topics shows how far the author follows the older, empirical methods of land-form classification. As one reads, he discovers further that the treatment is not regional in the ordinary sense of that term but rather a discussion of specific types of forms, classified systematically, with examples cited from abroad as well as from Italian regions. For this reason one may regard the accounts of "glacial regions" and of "deserts and steppes" as compensating in large measure for the failure to give them place in the avowedly systematic treatment of Volume I.

Each chapter of the second volume contains, in addition to a bibliography of authorities consulted, suggestions as to the best methods of studying different regional types. Some gaps in the bibliographies are notable. Thus in the literature on coral reefs the most important recent American contributions to the subject are conspicuous by their absence: Daly and certain others are not mentioned, while Davis escapes with the mention of one early paper on "The Home Study of Coral Reefs" and a general reference to "other works" without citations.

Rovereto writes as a geologist whose prime interest is in geologic history, geologic structures, and geologic processes rather than in the land forms which are the product of a part of these three elements. The subject matter of his work is presented as a series of facts classified according to geologic principles and not as a sequence of forms occurring in a systematic evolution of the earth's surface features. It is geology rather than geomorphology and often covers ground that even remotely is scarcely related to geomorphology. But both geologist and geographer will find the work full of interesting matter. The illustrations are abundant; and, while many of them are marred by poor reproduction, others are admirable, especially those showing detailed structural features. The author has gathered with care and placed at the service of science a goodly harvest of the beautiful geological illustrations in which Italy is so rich.

DOUGLAS JOHNSON

NOTES ON ENVIRONMENTAL CONTROL

FRANKLIN THOMAS. **The Environmental Basis of Society: A Study in the History of Sociological Theory.** vii and 336 pp.; ill., bibliogr., index. The Century Co., New York and London, 1925. 9 x 6 inches.

This is a book of notes on environment in relation to human society, rather than a scientific treatise. The author expounds the doctrines but professes to make no attempt "to pass judgment upon their scientific validity." The result is a readable and even an interesting essay upon causation and determinism and the opposing views of those who hold lightly the principle of environmental control or influence. In such a plan the dependence is not upon original but secondary sources; the opinions given are those which in the judgment of the compiler merited attention by opinion-forming persons more or less interested in social science. We question the value of the method. What we do need is a scientific statement (by a societologist or a geographer, let us say) based upon test cases in which the author has dug beneath the surface of things, dug deep wells here and there, and placed a foundation pillar or two on solid rock. In every age a certain amount of rewriting must be done to conserve the wisdom of past generations or adapt it to later social and economic forms and uses; in just this period we need less of secondary and far more of original material in the field of environmental "control." With his introduction out of the way, will Mr. Thomas tackle the main text?

A GREAT NATURALIST

W. F. BADÈ. **The Life and Letters of John Muir.** Vol. 1, ix and 399 pp.; ill.; Vol. 2, 454 pp.; ills., index. Houghton Mifflin Co., Boston and New York, 1924. $7.50. 8 x 5½ inches.

Conservation, "the preservation of specimen sections of natural flora—bits of pure wildness," the constant ideal of John Muir's life, which his abounding energy translated into so many glorious actualities, shines forth again, as in the great naturalist's own writings, in this collection of letters and illuminating comments thereon, by his friend Professor Badè.

The success of his efforts to conserve the scenic magnificences and noble examples of vegetation in the Yosemite and Sequoia National Parks, after his years of exploration and forceful writing had made his influence powerful with the aid of such friends as Theodore Roosevelt, is shown in many vigorous letters. Professor Badè tells a bit of unwritten history, of the trip into the High Sierras which he made with Roosevelt, the two escaping a horde of politicans who sought to influence the President against Muir's views. Muir had planned a trip to Europe with Professor Sargent

but postponed it, explaining that he might be able to "do some forest good in freely talking around the camp fire." Which he did, for he and Roosevelt became fast friends, and the President trebled the area of the National Forests and doubled the number of National Parks during his administration.

On the personal and family side the letters show the unfailing sweetness of Muir's character. Also revealing his kindly humanity are his visits, after many years, to friends in many states who had befriended him in his rambles: likewise his letters to his botanist friends, Torrey, Gray, Kellogg, and Parry. His enjoyment of storms, such as that on Mt. Shasta, is shown in several vivid letters—for him a great storm was nothing to be feared but only "a cordial outpouring of Nature's love."

RAYMOND H. TORREY

HUMAN GEOGRAPHY

JEAN BRUNHES. **La géographie humaine.** 3rd edit. Vol. 1: **Les faits essentiels groupés et classés; principes et exemples.** xi and 574 pp.; maps, diagrs.; Vol. 2: **Monographies; liaisons avec les disciplines voisines.** pp. 575–975; maps, diagrs., indexes; Vol. 3: **Illustrations hors texte.** 163 pp. Librairie Félix Alcan, Paris, 1925. 110 fr. 10 x 6½ inches.

In the essential modesty of his claims lies the great merit of Brunhes' geographical scholarship. He does not demand for geography more than its due, strictly refraining from attributing to it influences on human life that would better be attributed to other causes. He never loses the sense of reality: his feet remain firmly planted on the ground; he does not climb aloft into airy structures of hypothesis or system. The time will not be ripe for broad generalizations, he thinks, until many more detailed studies have been completed by competent geographers trained in modern methods. Brunhes has thought deeply enough in his chosen field to see that in the present stage of its development the foremost problems are less those of theory than of fact. "La géographie doit être de plus en plus une 'description explicative' de la surface du globe,—oui certes 'explicative'—mais tout de même et d'abord une 'description.' Même alors qu'en présence de faits de géographie physique ou de géographie humaine 'l'explication' ne serait point décisive ni complète, la description peut etre et doit etre rigoureusement précise." What facts are pertinent and what are not? How shall the pertinent facts be observed, classified, interpreted? These are the main problems. Let the "laws" and "principles" emerge later as the subject grows more mature.

The first edition of "La géographie humaine" appeared in 1910 (reviewed by Mark Jefferson, *Bull. Amer. Geogr. Soc.*, Vol. 43, 1911), the second in 1912, and an English edition edited by Isaiah Bowman and R. E. Dodge in 1920. Though some of the details were brought up to date in the English edition, it represented in the main the pre-war Brunhes. A chapter on the Central Andes had, however, been substituted as a type of natural unit for one on the Val d'Anniviers. A hearty welcome, therefore, should greet the new edition, in which the text has thoroughly been worked over in the light of the events of the past fifteen years. The new material includes two complete chapters; the one on the Central Andes from the English translation and a chapter dealing with roads in a new country (French Indo-China). The chapter on pedagogy has been omitted. Attention has been directed to recent geographical developments in circulation (transportation), in the utilization of "blue coal" and "white coal," in the cultivation of rice, cotton, silk, wool, and rubber, in the extraction of coal and oil and the industrial changes dependent thereon, in the study of the habitations of France, of nomadism and transhumance, of medical geography, and of other important topics. The bibliographical references throughout have been expanded to include the latest publications.

CORRECTION

On the map of the climatic provinces of the earth by Köppen published several years ago in the *Geographical Review* (Vol. 8, 1918, Pl. II) and in the accompanying text (p. 189, footnote 5), the position of the numbers 8 and 9 in the explanation of the symbols is incorrect. They should be reversed so as to make the explanations read "8, cold climate with wet winter" and "9, cold climate with dry winter." The patterns in the legend of the map will then also correctly correspond with the patterns on the map itself. This mistake goes back to the incorrect key of the colored map in *Petermanns Mitteilungen* (Vol. 64, 1918, Pl. 10) of which the *Review* map was a black-and-white rendering. Köppen's text (*ibid.*, p. 196) is correct on this point.

This error, insignificant in itself, is, however, worthy of mention as it affects so fundamental a work and, in one case, at least, has led to a misinterpretation (in Hermann Wagner's computation of the areas of the climatic provinces, *Petermanns Mitt.*, Vol. 67, 1921, pp. 216–217), as Professor Werner Werenskiold of the University of Oslo has kindly pointed out to us. The error is rectified in Erich Obst's quotation of that calculation (A. Defant and E. Obst: Lufthülle und Klima, in Enzyklopädie der Erdkunde, Leipzig, 1923, p. 172). It has also been rectified in the reprinting of the *Geographical Review* black-and-white map, with credit, in the *Monthly Weather Review* (Preston E. James: Köppen's Classification of Climates: A Review, Vol. 50, 1922, pp. 69–72), and, without credit, in Köppen's "Die Klimate der Erde: Grundriss der Klimakunde," Leipzig, 1923.